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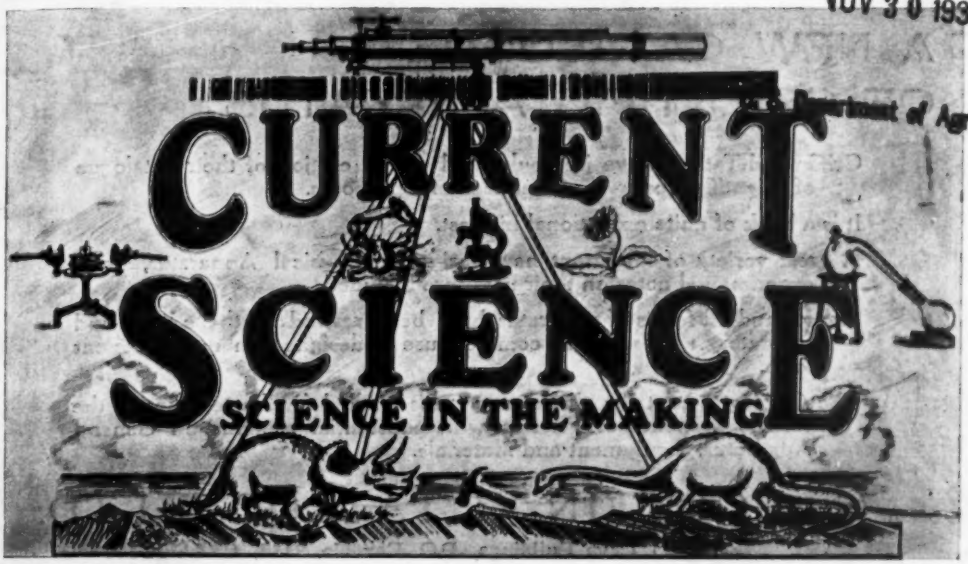

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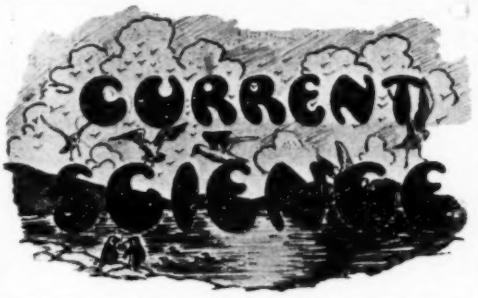

Vol. III] OCTOBER 1934 [No. 4

CONTENTS.

	PAGE
Science and Happiness	131
The Deccan Traps: Are They Cretaceous or Tertiary. By B. Sahni, D.Sc., Sc.D.	134
Some Recent Advances in Indian Geology. By W. D. West	137
Technological Researches at the University of the Punjab	144
Intra-Molecular Rotation in Organic Compounds. By M. A. Govinda Rau, M.A., Ph.D.	145
Study of Plant Tissue Fluids. By B. N. Sastri, M.Sc., A.I.C., and M. Sreenivasaya, B.A., F.I.I.Sc.	150
The Origin of the Santra Orange. By S. S. Bhat, M.Ag.	151
Letters to the Editor:	
Elimination of Bias due to Selection. By S. R. Savur	152
Rectification Phenomenon in Pyrolusite Crystal. By S. R. Khastgir and Anil Kumar Das Gupta.	153
The Band Systems of $CaCl_2$. By R. K. Asundi..	153
Additional Bands in the Band System of Sulphur. By R. K. Asundi	154
Influence of Dissolved Electrolytes on the Constitution of Water. By C. Sambasiva Rao	154
Change of Resistance of Cobalt in Longitudinal Magnetic Fields. By Md. Sharf Alam ..	155
Smoke Pollution in Bombay. By Y. G. Naik ..	156
Dry Ether as Solvent for Anhydrous Aluminium Chloride in Organic Synthesis. By R. C. Shah.	157
The Biological Oxidation of Inositol. By B. C. Guha and N. Das	157
A Preliminary Note on the Morphology of the Aerial and Underground Flowers of *Commelina benghalensis*, Linn. By P. Maheshwari and Bahadur Singh	158
A Note on the Presence of Parietal Cells in the Nucellus of *Convolvulus arvensis* L. By Kanhaiya Lal Mathur	160
The Female Pre-pupa of *Aptinothrips rufus*. By U. S. Sharga	161
The Multiplication of Scientific Societies. By B. C. Guha, and Reply by Gilbert J. Fowler ..	162
Research Notes	163
Irrigation Research in the Punjab	167
The Art of Chromium-Plating. By K. B. Parekh ..	171
Science Notes	172
Reviews	176
Forthcoming Events	180
The British Association for the Advancement of Science, Aberdeen, 1934 (*Supplement*)	i—xii

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Science and Happiness.

FROM a human standpoint, the concluding portion of Sir James Jeans' presidential address to the British Association is perhaps the most interesting. Within recent times there has been quite a volume of indiscriminate criticism about the benefits of science, and almost all the travail from which the world is suffering is attributed by a section of public opinion to the progress of scientific knowledge in its applications to the practical problems of life. Assuming that there is an element of truth in such an accusation, we are unable to discover a means of escape. Scientific knowledge has now become an integral part of modern culture, and its advancement is bound to be rapid in view of the assured provision for its encouragement, and few can control its direction and output. It is practically useless to suggest the abolition of scientific inventions or to stop scientific researches in any one country, without other countries undertaking similar obligations. Even if such a proposal were feasible, the net result would be to petrify society, but the hopes of restoring to man his happiness and peace the loss of which he is generally in the habit of laying at the door of science, would be as far from realisation as ever. Science has widened our outlook and augmented our store of knowledge; but it has also failed to enrich our moral endowment. It is equally true that scientific industrial planning will displace more labour than it can absorb, and all efforts to establish a balance between labour-saving devices and unemployment are bound to be futile.

We cannot ignore the innate tendency of man to press every kind of knowledge into his service, no matter to what branch of science and art it may belong. To acquire control over the forces of Nature or to perfect the methods of investigating the facts and phenomena of objective reality, is not in itself fatal to the well-being of man; but the end which he uses the scientific knowledge to achieve, makes a wide difference. Knowledge is neither moral nor immoral. It places in our hands the power of dignifying and saving human life; it also puts at our disposal the weapons of destroying it on a scale to which history scarcely furnishes a parallel. If in the past the Church and the State complacently permitted religious differences to lead to bloodshed,

the highly organised modern society need not be shocked when national rivalries, stress of over-population, economic competition and tariff barriers occasionally result in the outbreak of hostilities. The conditions of international relations which generally precede conflicts are the product of scientific development, and the operations on the field when it is taken, pass under scientific management. It is difficult to foresee a time when wars will be totally abolished, though in future they will be less frequent; it is equally difficult to imagine whether any economic planning will produce a permanent and equitable adjustment of labour and capital on the one hand, and, on the other, remove the causes of industrial depression, arising from over-production and from a defective scheme of distribution. The conspicuous feature of the twentieth century is the increasing readiness with which the fruits of scientific labours are utilised for sophisticating the human wants and for gratifying the fundamental appetites of man. The gifts of science have been applied to render social life artificial, and naturally its reactions to the environment must partake of the characteristics of materialism. In moments of intellectual exaltation we are apt to ignore the basic fact that life, whether it manifests itself in an amoeba or man, is under the influence of jealousy which expresses itself in organisms seeking to gratify the appetites of stomach and sex. Centuries of religious and educational progress and the creation of stern public opinion have not succeeded in repressing the imperiousness of this sinister emotion; science is not concerned with disciplining it. It is idle to talk of creating a new Heaven on earth so long as this primitive passion continues to dominate the public and private life of the individual and is a potent factor governing international relations. Science in its manifold applications rather emphasises economic jealousies between highly organised nations and by favouring mass production tends to embitter labour.

There is a great deal of truth in what Sir Alfred Ewing said two years ago as the President of the British Association, *viz.*, "Science has given man control over nature before he has gained control over himself". The function of science in any civilised community is obviously two-fold. It furnishes those who pursue its path with a picture of the physical phenomena of Nature, and the laws under which they manifest themselves, and the direction and extent of their practical service to man. A scientific mind is purely intellectual and virtually ignores the value of other types of experience. The second function of science is to provide helpful guidance to society for consolidating its forces for advancing its higher destiny. In the fulfilment of this latter aspect of its function, the efforts of science are confronted by a play of emotional complexes which form the foundation of all modern states and societies. Political and social organisations can only enjoy the benefits of science conferred indirectly through workshops and industries, but can never hope to apply scientific methods and discipline to their evolution and development. The intellect of man is different from that of child; but his emotions, though restrained more often than those of a child can be, are, however, more sinister and destructive when they break out. The intellectualism of the twentieth century has still a strong background of crude passions and, if in the next stage of the evolution of mind, this background is replaced by moral responsibility for human thoughts and actions to a tribunal not built by man, we shall be pretty near to achieving universal happiness and peace. This is a dream; but it is pleasant to dream.

Science in the pursuit of her enquiry is generally intolerant of sanctity and traditional authority, and she reorganises her statistical and comparative method as the only approach to Truth. This is permissible in respect of values which science discusses objectively, without actually experiencing. But the business of life is higher; it prescribes standards of values which it experiences in its relations towards the universe; the experience is a complex of emotions which does not obey the laws and discipline imposed by the physical sciences. For the advancement of material progress, scientific investigations are indispensable, but for certain other aspects of social life, religious approach is the more important. Human experiences, requirements and ideals can be viewed and interpreted not only from the standpoint of objective sciences but also from that of religion. Their functions are complemental, and the seeming opposition between the two modes of approach to life is due to want of mutual understanding of the deeper significance and purpose of human existence. In a lower sense civilisation is material and in building

it, scientific results lend themselves to be used as the means for accomplishing selfish gains, and for destroying and constructing the external embellishments of social life. In its higher aspects, civilisation connotes the enrichment of the moral and spiritual endowments of man, involving a radical transformation of his mental attitude towards his fellow-beings. Theology undid what religion attempted to achieve in this direction; but science in giving us a deeper insight into man's relation to his environment and knowledge of his origin and nature, may still become the friend of religion to assist in the achievement of man's highest destiny. The divorce of religion from science has delayed the process of humanising the mind and should account for the numerous woes from which man suffers. In order that religion, whose progress has been retarded by theological doctrines and ecclesiastical superstitions, might overtake science, the latter is not required to suspend its activities, but to hasten slowly. Their co-operation must result eventually in humanising the mind; and the attainment of this object offers the hope of establishing universal concord and happiness.

It is true that civilisation is a term too elastic and impalpable to be defined, but as we understand it, it is synonymous with industrial progress, expansion of trade, multiplication of wants, speedy locomotion, over-population, unemployment problems and fears of invasion. It is pertinent to ask whether this civilisation has tended to enhance our respect for the sanctity of human life and for the rights of personal property; or has it tended to enable those that can afford to provide themselves with material comforts, to enjoy them in peace and security? The gifts of science turn into blessings or curses, in proportion to the humanisation of the mind, dealing with them. The humanised mind intuitively acts upon the standard of absolute values set up by science and religion, for constantly checking the estimates of good and evil in our own nature. The impulses and motives which guide human actions in a world of material civilisation are, with honourable exceptions, dominantly personal, but under the combined influence of science and religion, they are expected to promote universal happiness. This fundamental transformation of the human mind is civilisation in its true and higher sense, and it is a consummation in the attainment of which science and religion have to co-operate for centuries.

It is pedantic to define happiness, but every one who has a healthy body and a clean and benevolent mind which are at peace with one another and with the environment, must have experienced it. Science can make life comfortable though not for all; but life yearns for happiness, now and hereafter. Universal happiness cannot exist so long as public life continues to be disfigured by folly, lust, crime, poverty and squalor, which are the concomitants of material civilisation which has no use for the absolute values of life proclaimed and taught by religion. Religion is opposed to organised ecclesiasticism and theological doctrines which have divided and embittered mankind. The Empire of religion is over the purer and finer emotions of love and joy as they spring from the undefiled heart.

In a society where comforts can be purchased by money, their enjoyment becomes obviously restricted to a few. The wealth which an industrial civilisation produces acquires an artificial power and value. Its drawbacks form the theme of economic science. Is it beyond the wit of man to invent a new type of coinage which will be sufficient for the needs of modern life, and which can neither be hoarded nor melted, possessing at the same time some measure of immunity for resisting the fluctuations to which the existing currency is periodically subject? Gold and beauty have by their rarity been the cause of the world's miseries. If we cease to attach any value to them, their possession will not elevate us and their loss will not depress us.

The new forces of the twentieth century have no relation to the noble traditions of the great historical civilisations. We assume that the multiplication of schools tends to the general refinement of mind, and the increased output of industrial products, to the promotion of happiness. We further assume that ability to invent delicate instruments for scientific research has raised the stature of scientific genius. Science has its own limitations, but in collaboration with humanism, it may some day succeed in producing a combination of circumstances favouring the appearance of new human chromosomes and genes transmitting to the successive generations, those worthy qualities which adorn life and make it happy. This is not a meditation. The

scientific humanism about which we read so frequently in current literature envisages a new civilisation, in which the arts and sciences will be studied "with a genuine devotion to the Good, the True and the Beautiful" and in which the qualitative values of human life and its ideals will not be distorted by industrial progress. Science and human nature are essentially reconcilable. Scientific civilisation ought to produce a change in the attitude and temper of mind radically different from what at the present moment are the dominating motives of individual and corporate action. Human nature being what it is, its transformation must occupy time not easily calculated, but in the meantime the question proposed by Sir James Jeans has to be answered. He asks, "Is it not better to press on in our efforts to secure more wealth and leisure and dignity of life for our own and future generations, even though we risk a glorious failure, rather than accept inglorious failure by perpetuating our present conditions, in which these advantages are the exception rather than the rule?" To strive to enrich the gifts of science is worthy, but to spread their beneficence for the uplift of human nature is nobler.

The Deccan Traps: Are They Cretaceous or Tertiary?

By B. Sahni, D.Sc., Sc.D.

Department of Botany, University of Lucknow.

IN the history of Science it has sometimes happened that a pioneer, working with a freer mind than it is perhaps possible to keep now-a-days with the influence of a long literature behind us, has arrived at conclusions which have ultimately proved to be sound, although they were long disputed by those who came after him. The object of the present note is to draw attention to what is probably another instance of this kind.

The older geologists Malcolmson,[1] Hislop and Hunter[2] and even T. Oldham[3] as late as 1871 regarded the Deccan Traps, on account of the fossils contained in the so-called Intertrappean beds, as early tertiary. Hislop and Hunter compared the flora, of which a large collection of fruits, seeds, etc., was then available, with the Eocene flora of the London Clay, which Bowerbank[4] had described only a few years previously. Owing to certain unfortunate circumstances, which I hope to relate elsewhere, this important direct evidence of a tertiary age was allowed to recede into obscurity and oblivion; while indirect evidence, regarded as indicative of a cretaceous age and culled from distant areas like Sind and Baluchistan[5] or from the underlying Lameta series,[6] of which the exact relations with the traps are still an open question, has in recent years held almost undisputed field. In 1893, when the second edition of the Indian Geological Survey's official manual[7] was published, the whole question was discussed in detail on the evidence then available; but the conclusion there expressed was distinctly cautious and non-committal. Today, the official view of the Survey[8] although admittedly based solely upon indirect evidence, regards the Deccan beds, almost without question, as belonging to the close of the mesozoic and not to the opening of the tertiary era. Until quite

[1] Malcolmson, *Trans. Geol. Soc., London*, 1837, **5**, 537; reprinted in Carter, *Geol. Papers on Western India*, 1857, 1-47.

[2] Hislop and Hunter, *Quart. Journ. Geol. Soc.*, 1855, **11**, 345; reprinted in Carter, *loc. cit.*, 247, *q.v.*; see also Hislop, *Journ. Bombay Asiat. Soc.*, 1853, **5**, 58-76; *Proc. Bombay Asiat. Soc.*, 1853, **5**, 148-150.

[3] Oldham, T., *Rec. Geol. Surv. Ind.*, 1871, **4**, 77.

[4] Bowerbank, *History of the Fossil Fruits and Seeds of the London Clay, London*, 1840.

[5] D'Archiac and Haime, *Descr. d. animaux foss. du groupe Nummulitique de l'Inde, Paris*, 1853; Duncan and Sladen, *Palæont. Indica*, 1871-1885, Ser. XIV, **1**, (iii, 1); Douvillé etc., *Palæont. Indica, N.S.*, 1927-1929, **10**, mem. 2, 3; but see also Holland, *Ind. Geol. Terminol., Mem. Geol. Surv. Ind.*, 1926, **51**, 51.

[6] Matley, *Rec. Geol. Surv. Ind.*, 1921. **53**, 142-164; see also Medlicott, H. B., *Rec. Geol. Surv. Ind.*, 1872, **5**, 115-120; Oldham, T., *loc. cit., supra*, 1871; Wadia, *Geol. of India*, 1926, pp. 190-191; Holland, *loc. cit.*, 1926.

[7] Oldham, R. D., *Manual of the Geology of India* (G.S.I. publication), 1893.

[8] Holland, "Indian Geological Terminology", *Mem. Geol. Surv. Ind.*, 1926, **51**, 64, 88; see also Wadia, *Geol. of India*, 1926, 200.

recently I was one of those who freely accepted this view. But a comprehensive review of the evidence, including some recent discoveries, has led me to abandon this opinion in favour of the conclusions reached by the pioneer workers.

I am deeply indebted to various officers of the Geological Survey and particularly to the distinguished head of that Department, Dr. L. L. Fermor, F.R.S., for their great courtesy in acquainting me with the geological literature in support of the official view and in replying to several other enquiries. I have no intention here, nor am I competent, to discuss this literature which must be familiar to all Indian geologists. My main purpose is to draw attention to the fact that *there is a considerable body of direct palæobotanical evidence, and that this evidence, as I stated in a recent note*[9], *points distinctly in favour of a tertiary age for the Intertrappean series.* I may say in passing, however, that while the fauna has been pronounced to be indecisive from the stratigraphical point of view[10] (most of the genera having long ranges in time), if the crustacean remains which Malcolmson[11] recorded from the Deccan beds nearly a century ago were correctly assigned to *Cypris*, we have some little evidence pointing in the same direction, even from the animal side because this genus is unknown in rocks older than the tertiary. But of course, until the reference to *Cypris* has been confirmed the evidence of the fauna must be regarded as neutral.

As for the plant remains, a provisional list with references to earlier papers was given in the preliminary paper already cited.[12] Since then, under very unusual circumstances, I have unearthed from the vaults of a Bombay museum an important old collection of silicified palms and dicotyledons, some of which were no doubt collected over a hundred years ago. This newly discovered, or rather re-discovered, material lends further support to the view I had already expressed. The whole of the Intertrappean material in hand is now being described in detail in collaboration with my research students Messrs. B. P. Srivastava, H. S. Rao and K. M. Gupta. Till this has been done, detailed comparisons cannot be made, but enough work has been accomplished to show that the assemblage as a whole cannot be compared with any known cretaceous flora: it is distinctly a tertiary assemblage, and probably a lower tertiary one. I may also add that the whole of this material comes from the lower part of the Intertrappean series and not from the regions to the south and west, where the rocks are even younger, those at Bombay, representing the top of the series, being several thousand feet higher.

The main arguments for a tertiary age are the following:—

(*a*) *The very large proportion of palms among the angiosperms in the Intertrappean flora.*—This proportion is even larger than would appear from the preliminary note cited above. Without committing myself to exact figures I may say that at the present moment, out of a total number of not more than 42 angiosperm species which have come to my notice, there are no fewer than 23 species of palms (18 of *Palmoxylon*, and at least 5 of fruits, besides one or two of leaves). Even allowing that all the fruits and leaves belonged to some of these 18 *Palmoxyla*, and making no such allowance in the case of the dicotyledonous fruits and leaves, the proportion of palms among the angiosperms remains strikingly high. It is generally agreed that the palms first arose in the cretaceous and rapidly increased and spread during the tertiary, when the family attained the zenith of its development. In no known cretaceous flora do the palms figure at all so prominently as they do in the Intertrappean flora.

(*b*) *The genus Azolla*, indeed the family Hydropterideæ as a whole, has never been recorded from rocks older than the tertiary. Both the previously described species, *A. prisca* Reid and Chandler[13] and *A. tertiaria* Berry,[14] come from tertiary strata.

(*c*) *The occurrence of Nipadites, a typically eocene genus.*—In the winter of 1930 the enthusiastic Benares geologist K. P. Rode

[9] Sahni, Srivastava and Rao, "The silicified flora of the Deccan Intertrappean series," 1934, Parts I-IV, *Proc. Ind. Sci. Congress*, Botany Section, Bombay meeting, read January 1934, published March 1934.

[10] Wadia, *Geology of India*, 1926; R. D. Oldham, *loc. cit.*, *supra*, 1893.

[11] Malcolmson, *loc. cit.*, *supra*, 1837.

[12] Sahni, Srivastava and Rao, *loc. cit.*, *supra*, 1934.

[13] Reid and Chandler, "The Bembridge Flora," *Brit. Mus. Catalogue*, 1926.

[14] Berry, *Proc. U. S. Nat. Mus.*, 1927, **72**, p. 4, pl. 1, figs. 9-10. Sporocarps were not observed, hence final proof of *Azolla* is lacking in this species.

brought to me at Lucknow a small but interesting collection of fossil plants collected by him near his own village Mohgaon Kalan, east of Chhindwara, in one of the basal members of the Intertrappean series. Among these I at once recognised an undoubted species of *Nipadites*, which thus confirmed Hislop's record of this genus, now eighty years old.[15] There were also some trilocular fruits specifically identical with specimens already lent me by the British Museum, as well as one or two new forms, and several species of *Palmoxylon*, three of which he described at my suggestion.[16] I had also suggested that he should describe the fruits, but unfortunately his paper on these,[17] unlike those on the *Palmoxyla*, was sent to press without my knowledge, and it contains a number of blunders. Nevertheless the importance of the discovery of an undoubted *Nipadites* (*N. hindi* Rode) in the Intertrappean beds must be fully recognised, although Rode himself did not see it. While it may be a matter of opinion whether this fossil should be placed in the genus *Nipadites* or referred to the modern genus *Nipa*, both the form and the structure which (with Mr. Rode's kind permission) I have described and figured in another paper, to be published shortly, leaves no doubt as to the affinity. There is no room for a spongy cavity above the seed, as there is in *Pandanus*[18]; there is a large basal aperture for the embryo to escape (not a "stalk-cavity" as described by Rode) and, lastly, the seed is very definitely grooved on one side as in the modern *Nipa* (not smooth as described by Rode). The angular form of the fruit, as well as the fibrous mesocarp (locally exposed by the abrasion of the thin epicarp) lends support to the affinity with *Nipa*. This discovery thus fully confirms the presence of *Nipadites* in the Intertrappean flora, first recorded by Hislop in 1853. The other species, named *N. compressus* by Rode, may or may not be a *Nipadites*. Nevertheless one of the most important points of resemblance with the London Clay flora has been fully established, and it gives the strongest support to an eocene age for the Deccan beds.

One more point seems important although Rode himself does not refer to it. *Nipadites* is not only a genus very characteristic of the eocene period but, unless these palms have changed their mode of life since then, its occurrence in the northern part of the Deccan indicates the existence of an *estuary*, during the early part of the Intertrappean period in the proximity of Chhindwara. In their valuable memoir on the London Clay flora recently published Reid and Chandler[19] have shown that nearly all the fossil records of *Nipa*-like palms "lie approximately along the margins of the ancient Nummulitic, or Tethys, sea and its extensions". So, most probably a north-flowing river debouched into the great Tethys sea or into an arm of that sea, not far to the north of Mr. Rode's home! We may now confidently look forward to the discovery of further evidence of an estuarine flora along the northern and eastern borders of the Deccan Trap area, perhaps particularly in the region of Rajahmundry, from where a brackish water fauna is already known.

The above, briefly, are the main considerations which taken together have led me, in spite of the official view of the Indian Geological Survey, to assign an eocene age to the Deccan Traps. This view not only vindicates the opinion expressed by the pioneer workers, but is also in consonance with the conclusion recently arrived at by Sir Arthur Smith Woodward, F.R.S.[20] from the indirect testimony of some fish remains from beds believed to belong to the Lameta series.

I cannot conclude this note without an expression of sincere thanks to Mr. Rode and also to Dr. Fermor and his colleagues, to whom I owe much of the information and material which I have here used, perhaps somewhat ungratefully, in support of opinions opposed to theirs.

[15] Hislop, *Journ. Bombay Asiat. Soc.*, 1853, **5**, 68; Carter, *loc. cit.*, 1857, 718; see also Hislop and Hunter, 1855, in Carter, p. 264.

[16] Rode, *Quart. Journ. Geol. Min. and Met. Soc. of India*, 1933, **5**, (ii, iii), *Calcutta*.

[17] Rode, *Curr. Sci.*, 1933, **2** (v), 171-172, *Bangalore*.

[18] Rode's fig. 2 on p. 172 is, however, hypothetical, as the distal half of the fossil has not been cut longitudinally.

[19] Reid and Chandler, "The London Clay Flora", *Brit. Mus. Nat. History, London*, 1933.

[20] Smith-Woodward, A., *Palæont. Indica, N. S.*, 1908, **3** (iii), 1-6; a view recently confirmed by him in a letter to me, dated 1934.

Some Recent Advances in Indian Geology.*

By W. D. West,
Geological Survey of India.

Introduction.

THE Editor of *Current Science* has asked me to contribute an article on recent advances in Indian geology. The following notes, dealing with certain aspects of the subject with which I am more familiar, have been put together in the hope that they may prove to be of interest not only to students of geology in India, but also to geologists outside India who have not the time to keep in touch with developments in this country.

Perhaps the most disturbing feature of modern scientific work is the immense output of literature which is continually appearing in every branch of science. So great is this becoming that it is a matter of difficulty for any worker to keep in touch with the progress that is being made, even in his own subject. This difficulty applies with particular force to geology. Modern geology has become so comprehensive, and its various aspects have become so specialised, that it has been said that there are no longer any geologists but only specialists in various branches; while specialists have been defined as those who know more and more about less and less. India is a large place, with a very varied geology and the considerable number of papers on Indian geology that are continually appearing, overburdened as they often are with the details of their subject, make it difficult for anyone not directly interested in them to appreciate fully the progress that is being made. In writing these notes, therefore, I have tried as far as possible to draw attention to the main lines along which our understanding of the geology of India is developing, rather than to summarise every paper that has recently appeared, which would in any case be impossible within the limits of a series of short articles.

I have divided this account into five sections: (1) The Archæan Rocks of Peninsular India, (2) Deccan Trap volcanic activity, (3) The geology of the Himalaya, (4) The geology of Burma, (5) The geology of the Salt Range. A section dealing with recent advances in palæontology by Mr. D. N. Wadia has already appeared in *Current Science* (December, 1933). The section on the geology of Burma is being contributed by my colleague Mr. V. P. Sondhi, to whom I am much indebted.

The Archæan Rocks of Peninsular India.

The Archæan rocks of India occupy a greater area than any other formation. They are important economically in containing rich deposits of gold, iron, manganese and mica. It is unnecessary to stress the importance of pure scientific research in the bearings which it may have on economic development: and a detailed study of the Archæan rocks in India, such as is being carried on in certain areas, needs no further justification. The problems associated with Indian Archæan geology are so many, and their proper discussion would be so laborious, that in the following notes only a very general account can be given of the main trend of recent work. It is unfortunate that most of this work is yet unpublished, and some indication of the lines along which it is developing may therefore prove to be of value.

The peculiar difficulties that beset the geologist who is endeavouring to interpret the geological history of Archæan times are well known. The metamorphism which these rocks have undergone has in some cases made originally dissimilar rocks appear similar, while in other cases the same rocks have been made to appear profoundly different in different places where they have suffered varying degrees of metamorphism. A further difficulty in the way of correlating these very old rocks is that many of their outcrops have become isolated from one another, either by the denudation of intervening tracts or by the superposition of later rocks; and it is difficult sometimes to be certain whether a difference observed in the rocks of two neighbouring but separated tracts is due to actual difference in the age of the rocks, or to lithological variation, or to the effects of varying metamorphism.

Before referring to the recent advances made in this branch of Indian geology a word may be given about the classification

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of these old rocks. This question of nomenclature is a thorny one, and perhaps the less said the better. But two points call for comment. It is becoming increasingly clear, more especially as the result of Dr. A. M. Heron's researches in Rajputana, that the old metamorphosed rocks of India of undoubted sedimentary origin have to be subdivided into two or three systems, separated from each other by big unconformities. The term Archæan was first introduced by Dana in 1872 to include all rocks older than the Cambrian.[1] But it is the custom in many countries to restrict its use to the more highly metamorphosed rocks older than the Cambrian, and to designate the less metamorphosed rocks as Pre-Cambrian or some such term. As regards India, in 1906 Sir Thomas Holland divided all rocks older than the Cambrian as follows:[2]

Purana	..	Cuddapah to Vindhyan.
Archæan	..	Dharwarian Eruptive gneisses and granites Schistose gneisses Oldest gneisses.

Such a classification, while it may have served a useful purpose nearly 30 years ago, is clearly inadequate at the present day. It is not proposed here to suggest any alternative. But the work that is gradually being completed in the several Archæan tracts in India, which is referred to in the following notes, should, after the effects of varying metamorphism and of changing lithology have been disentangled, lead in the end to a natural classification based on fuller data than are at present available.

The other point which must be referred to here concerns the use of the word 'Dharwar'. Until quite recently this name has been used to embrace all the bedded schists of Archæan age, including both metamorphosed sediments and contemporaneous lava flows.[3] But the recent work[4] in Rajputana and Bihar and Orissa has indicated the presence of two or more series within the Archæan, separated from one another by unconformities. The use of the term Dharwar in its original comprehensive sense can thus no longer be maintained. To avoid misunderstanding it will therefore be better in future to refer to the Archæan rocks of each tract by their local names, the term Dharwar being restricted to the rocks of the Dharwar district and adjacent tracts in Mysore. In this way no implication of correlation will be introduced into the nomenclature which is not justified by the known facts.

In the following account attention will be confined to the four tracts in which detailed work has recently been done.

RAJPUTANA.

In Rajputana Dr. A. M. Heron, who commenced work there in 1908, has now completed the mapping of the crystalline rocks, and the publication of the details of his work is being eagerly awaited. As a result of this work two points are clearly brought out which are of particular interest. First, the necessity of dividing the crystalline rocks of this area into four distinct groups or systems, separated from each other by marked unconformities frequently accompanied by conglomerates. Second, the remarkable way in which some of the oldest rocks in India are in certain places still in the condition of almost unaltered shales and slates.

As regards the former point, the crystalline rocks of Rajputana have to be divided into the following groups, given in order:

Delhi system
— — — — unconformity with conglomerate
Raialo series
— — — — unconformity with conglomerate
Aravalli system
— — — — — unconformity with conglomerate
Banded Gneissic Complex

Of these the Raialo series, which includes the well-known Makrana marble, is the smallest and least important, and is often missing.[5] The Banded, Gneissic Complex, to be distinguished from the injection gneisses formed by the intrusion of acid magma into the Aravallis and Delhis at a much later date, is thought to be the equivalent of the Bundelkhand gneiss of Eastern Rajputana, though the two are never seen in actual contact. They are mainly of igneous origin, but there do occur amongst them biotite- and chlorite-schists and granulites which may represent metamorphosed sediments greatly injected by both basic and acid rocks.[6] They are the oldest rocks in Rajputana.

Perhaps the feature of greatest interest which has been brought to light by Heron's

[1] *Amer. Jour. Sci.*, 3rd series, 1872, **3**, 253.

[2] *Trans. Min. Geol. Inst. Ind.*, 1906, **1**, 47.

[3] *E.g.*, L. L. Fermor, *Mem. Geol. Surv. Ind.*, 1909, **37**, 1120; and J. A. Dunn, *op. cit.*, 1929, **54**, 154.

[4] *Rec. Geol. Surv. Ind.*, 1886, **19**, 98.

[5] *Op. cit.*, 1929, **62**, 172.

[6] *Op. cit.*, 1930, **63**, 143.

work is the way in which the Aravallis are in places still in the condition of practically unaltered shales and slates. We have, in fact, in Rajputana one of the largest areas in the world of Archæan rocks which have suffered little or no metamorphism, perhaps only to be parallelled by the little altered Archæan rocks of Finland. The way in which such rocks have escaped metamorphism during Archæan and later times is one of the most interesting problems of Indian Archæan geology. When traced along the strike to the south these Aravalli rocks become injected with acid magma on an immense scale, and the rock becomes a banded gneiss.[7] Further south still the injection dies out, and slates are found once more. These composite gneisses are described by Heron as being exactly similar to the injection gneisses in Sutherlandshire, Scotland, recently described by H. H. Read. In Eastern Rajputana the Aravalli rocks rest unconformably on the eroded surface of the Bundelkhand gneissose granite, and there seems to be no doubt now as to the relative ages of these rocks.

The Delhi system provides a problem of correlation which makes the geology of Rajputana of such intriguing interest. For the rocks of this system, although belonging to a late period of Archæan geology, are considerably folded and highly metamorphosed. They are in fact in many parts of Rajputana more highly metamorphosed than the older Aravalli rocks. To understand how this has come about it is necessary to state that structurally Rajputana is dominated by the great Delhi synclinorium, which runs in a N.E.–S.W. direction in north-east Rajputana, swinging round to a N.–S. direction in southern Rajputana and Bombay. Heron describes it as having roughly the shape of an hour glass, being narrowest in the centre and splaying out in the north-east and in the south. This is due to the fact that in the centre the syncline is a simple fold, but to the north-east and to the south it becomes complicated by the appearance of many secondary folds, and the outcrop becomes much wider. The fact that the Delhi rocks in the centre of the synclinorium are more highly metamorphosed than the older Aravalli rocks, is thought by Heron to be due to the fact that they were more deeply buried and more greatly intruded by igneous rocks than the underlying Aravalli rocks which are only seen in the outer parts of the synclinorium.[8] This anomaly of metamorphic grade leads C. S. Middlemiss to adopt a reversed order of superposition for the Aravallis and Delhis in Idar State, at the south-west end of the synclinorium.[9] But Middlemiss, in investigating only a small area, was handicapped in being confined in his work to a comparatively short distance along the strike; and moreover the Delhi-Aravalli unconformity is not recognisable as such within Idar, while inversion and overfolding are general. The later work of Heron, carried on over a greater area, and including the tracing of the Delhi-Aravalli unconformity for something like 500 miles, and the mapping of the lower unconformity of the Aravallis upon the Bundelkhand gneiss and the banded gneisses, has settled definitely the age relations between the major rock groups of Rajputana.

In post-Delhi times the south-western side of the synclinorium was swamped with great intrusions of granite at two different periods. These igneous rocks, together with four different sets of basic intrusions and extrusions, have been described in detail by A. L. Coulson in his account of the geology of Sirohi State.[10] The first acid phase includes the Erinpura granite and its associated aplites and pegmatites, intrusive into both Aravalli and Delhi rocks. No volcanic rocks are found associated with this phase. The second phase of acid intrusion is known as the Malani system. It includes the Idar granite as the plutonic phase, a variety of quartz-porphyries, felspar-porphyries, granophyres and similar rocks as the hypabyssal phase, and rhyolites and dellenites as the volcanic phase, including the well-known Malani rhyolites. Of considerable petrographical interest is the suite of igneous rocks intruded into the Erinpura granite near the village of Mundwara, on the western border of the State. These include picrites, gabbros and dolerites, basalts and pyroxenites, sodalite-syenites, and agglomerates. The memoir is accompanied by a large number of chemical analyses, which add to the interest of the petrographical descriptions.

On the eastern side of the Delhi synclinorium, B. C. Gupta has described the geology

[7] *Op. cit.*, 1929, **62**, 171-172.

[8] *Op. cit.*, 1931, **65**, 143-144.

[9] *Mem. Geol. Surv. Ind.*, 1921, **44**, pt. 1.

[10] *Op. cit.*, 1933, **63**, pt. 1.

of Central Mewar in a memoir which is now in the press.[11] The paper is of value in giving a detailed description of the Banded Gneissic Complex and of the Bundelkhand gneiss. Although the two are everywhere separated by a belt of Aravalli rocks, and although where seen on either side of the belt they are markedly different, Gupta agrees with Heron in regarding them as roughly the same. He looks upon the Bundelkhand gneiss as having crystallised under very deep-seated conditions, while the gneissic complex with its heterogeneous structure is thought to have been formed in a higher zone of the earth's crust, where there was more opportunity for the incidence of directed pressure, as well as a fairly high temperature. The Aravallis rest on both with an erosion unconformity, sometimes accompanied by conglomerates.

CENTRAL PROVINCES.

In the Central Provinces, what is undoubtedly the most detailed mapping that has so far been attempted in Indian Archæan geology has been carried out by Dr. L. L. Fermor and his co-workers in the Nagpur, Chhindwara and Bhandara districts. It is a matter for regret that the full details of this work are unlikely to be published for some time to come, though summaries are to be found in the Director's annual reports.[12]

This series of Archæan rocks, named the Sausar series, are economically important for the rich deposits of manganese ore that they contain. They have been divided up into a number of stages which have a remarkable constancy over the area in which they have so far been mapped. These stages are so distinct, and their order now so well established, that it is worth while giving them in detail here, for comparison with other areas.

Sitapar stage ..	Hornblende-schists.
Bichua stage ..	*Pure facies:* white dolomitic marbles, with serpentine, tremolite, and diopside. *Impure facies:* diopsidites, actinolite schists, and schists with wollastonite, grossularite, tremolite, and anthophyllite.
Junewani stage ..	Muscovite-biotite-schists with autoclastic conglomerates.
Chorbaoli stage (?=Ramtek stage)	Quartzites and muscovite-quartz-schists.
Mansar stage ..	Muscovite-biotite-sillimanite-schists, with lenticular beds of manganese ore.
Lohangi stage ..	Pink calcitic marbles and calciphyres.
Utekata stage ..	Banded calc-granulites.
Kadbikhera stage	Megnetite-biotite-granulites.

The Ramtek stage was originally given a separate position, but it is probably identical with the Chorbaoli stage. All these stages with the exception of the Sitapar stage, the hornblende-schists of which probably represent metamorphosed lava flows, are now regarded as of sedimentary origin.

In the Sausar tahsil and in the northern part of the Ramtek tahsil these rocks display a very high grade of metamorphism, the characteristic pelitic rock being a garnet-sillimanite-biotite-schist, while in the dolomitic rocks the mineral wollastonite occurs. But traced to the south and to the east the grade of metamorphism decreases, so that while in the northern and western parts of the area the manganese ore occurs in a muscovite-biotite-sillimanite-schist, with or without garnet, in the southern part of the area, around the manganese mines of Kandri and Mansar, the country rock is a muscovite-phyllite or schist, in which biotite is very subordinate. In both cases the stage is the same, being overlain and underlain by the same rocks in both areas. Accompanying the increasing metamorphism in the north there is a great abundance of pegmatite intrusions.

The complexity of the folding in these rocks is very great, and W. D. West has brought forward evidence for the existence of a 'nappe' in the vicinity of Deolapar, in the Ramtek tahsil, whereby slightly different lithological facies of the Sausar series, originally deposited far apart, have been brought into juxtaposition with one another.[13]

In addition to these metamorphosed sedimentary rocks, there are a variety of porphyritic and fine grained granites, pegmatites and ortho-gneisses which are younger than the Sausar series. There is also a gneiss which has gone by the general name of 'streaky gneiss'. In places this occupies as great an area as the Sausar series. It has been shown by West that much of this rock is really a composite or injection gneiss, formed by the intimate penetration of an igneous granulite of granodioritic

[11] *Op. cit.*, 1934, **65**, pt. 2.

[12] See especially, *Rec. Geol. Surv. Ind.*, 1931, **59**, 143-44 and *op. cit.*, 1931, **65**, 100-101.

[13] *Rec. Geol. Surv. Ind.*, 1931, **65**, 102-104.

composition by abundant veins of aplite.[14] Similar injection has affected the more schistose members of the Sausar series, especially the Mansar stage. All these gneisses are definitely younger than the Sausar series, and there seems to be nothing in this area comparable to the banded gneissic complex of Rajputana, upon which the Sausar series might have been laid down.

To the south and south-east of this tract of the Sausar series there occurs an area of very much less metamorphosed rocks, known as the Sakoli series. These have been studied by D. S. Bhattacharji and S. K. Chatterjee, who have shown them to consist of phyllites and slates, hæmatite-sericite-quartzites, chlorite-schists and jaspilites.[15] They are mostly separated from the Sausar series by alluvium; but where the two series are seen adjacent to one another the evidence suggests that the Sakoli series are but the upward continuation of the Sausar series. The much lower grade of metamorphism is due, according to Chatterjee, to their having suffered retrograde metamorphism. They will be referred to again below.

Bihar and Orissa.

Turning now to the third area in northern India where detailed work has been done, Bihar and Orissa, we find that, excluding younger pre-Cambrian rocks which are perhaps of Cuddapah age, there are three distinct lithological series of Archæan age, as follows:

Iron-ore series, with Dalma volcanic flows and tuffs at the top.

Gangpur series, limestones and schists with manganese ore.

Older Metamorphic series.

The oldest, composed mainly of hornblende-schists and quartzites, resemble lithologically the Dharwars of South India. The Gangpur series, recently mapped by M. S. Krishnan, show a considerable resemblance to the Sausar series.[16] Dr. Fermor has always maintained that the manganese ores of India very probably occupy a single horizon within the Archæan, and in Gangpur State the presence of manganese ore and of both calcitic and dolomitic limestones suggests a correlation with the Sausar series. These rocks are separated from the Iron-ore series by a belt of crushing, so that the relation between the two is obscure. They bear, however, no lithological resemblance to one another, although found in adjacent tracts. The Iron-ore series are found resting with a strong unconformity upon the Older Metamorphic rocks, as first shown by H. C. Jones.[17] They are too well known to need description, but J. A. Dunn's recent memoir brings out well the way in which a single series of rocks may show very different grades of metamorphism in different places.[18] In South Singhbhum the Iron-ore series is little metamorphosed or disturbed; but northwards both the metamorphism and the folding increase, until in North Singhbhum the rocks are highly metamorphosed and severely folded. Previously the Iron-ore series, partly on account of its little metamorphism in South Singhbhum and partly on account of the fact that it rests unconformably on older metamorphic rocks, had been regarded by Jones as likely to be of Cuddapah age, the underlying metamorphic rocks being referred to as Dharwar. Both these series are now included by Dunn within the Dharwar system, using the term Dharwar as synonymous with metamorphosed Archæan sediments and including all the schists below the Eparchæan unconformity. The chief reason he puts forward for supposing them to be older than Cuddapah age is that they are intruded by gneissic granites which are themselves intruded by dolerites (in places metamorphosed to epidiorites). And since no intrusions of dolerites have been known in Peninsular India between Cuddapah and Rajmahal (Jurassic) times, it is deduced that the Iron-ore series, the granites, the dolerites, and the folding and metamorphism are all older than Cuddapah, and therefore Archæan in age.

The Chota Nagpur granite-gneiss, and the Singhbhum and other granites, have been studied in detail by Dunn and by L. A. N. Iyer.[19] They are intruded into the Iron-ore series, but are all regarded as Archæan in age. The reaction between these granites and the country rocks, which has given rise to hybrid rocks and synantetic minerals, is discussed by Iyer, who has also

[14] *Op. cit.*, 1933, **67**, 304.

[15] *Op. cit.*, 1929, **62**, 132-133 and *op. cit.*, **65**.

[16] *Op. cit.*, 1933, **67**, 63-65.

[17] *Op. cit.*, 1922, **54**, 41.

[18] *Mem. Geol. Surv. Ind.*, 1929, **54**.

[19] *Ibid.*, chaps. X and XI; and *Rec. Geol. Surv. Ind.*, 1932, **65**, 490.

furnished a number of chemical analyses of the various granites.

SOUTH INDIA.

In 1886 R. Bruce Foote mapped the rocks around Bellary and Dharwar, south of the great Deccan Trap outcrop.[20] The belts of schistose rocks which overlie the main gneissic foundation, consisting of hornblende schists, chlorite-schists, quartzites, banded hæmatite-quartzites, limestones and conglomerates, were named by him the Dharwar system, and were thought to overlie the gneisses unconformably, which were therefore regarded as the older. Subsequent work, however, has shown that these gneisses frequently show intrusive relations towards the Dharwars, and they are now regarded as younger. As regards the nature of the Dharwars, it was formerly assumed that, apart from the hornblende schists and epidiorites, the majority were metamorphosed sediments. Of late, however, the Mysore Geological Department have concluded that nearly all the rocks of the Dharwar system are of igneous origin, while the conglomerates are regarded as autoclastic. This point of view is summarised by W. F. Smeeth in 'An Outline of the Geological History of Mysore', in Bulletin No. 6, Department of Mines and Geology, Mysore State. With reference to this change of view, C. S. Middlemiss in 1919 wrote as follows:[21]

> 'So far I think I am right in saying that no graphic representation of these extraordinary wholesale transformations of granites, quartz-porphyries and other igneous rock types, into schists, conglomerates, limestones and quartzites, has as yet appeared from the pencil of any of those responsible for the statements.'

So far as I am aware this detailed information is still not forthcoming, though it may probably safely be assumed that some at any rate of the rocks formerly regarded as sedimentary are of igneous origin, and that some of the conglomerates are autoclastic. It appears, however, that not all the geologists of the Mysore Geological Department are in agreement over the origin of these rocks, B. Rama Rao in particular suggesting that some of the crystalline schists may be metamorphosed sediments.[22]

In the above-mentioned paper Smeeth describes the Dharwars as being broadly divisible into an upper group consisting mainly of chlorite-schists, and a lower group consisting mainly of hornblende-schists. The granites and gneisses, now regarded as younger than the Dharwars, cover by far the greater part of the area. They include various types, of which the more important are the Champion gneiss, the peninsular gneiss, the Charnockite series, and the Closepet granite, in order of age. An account of these is given by Sampat Iyengar in his presidential address before the Indian Science Congress.[23]

Compared with the Archæan rocks of other parts of India, the true Dharwars of the Dharwar district are lithologically similar to the Champaner series in Bombay, which have now been shown by Heron to be identical with the Aravalli system of Rajputana.[24] It is possible that the Aravalli rocks are continued southwards beneath the Deccan Trap to emerge in Dharwar and Mysore as Dharwar rocks. Recently considerable attention has been paid to some manganiferous marbles, spessartite-rocks and tarurites (veined hornblende-schists with secondary pyroxene) which occur near a place called Sakarsanhalli, in the Kolar district of Mysore State. Dr. Fermor considered these rocks similar to the manganiferous rocks in the Sausar series.[25] They were thought by B. Jayaram of the Mysore Geological Department to belong to a low horizon in the Dharwars, or even to an older series.[26] Later they were examined and mapped by P. Sampat Iyengar, who concluded that these varied rocks are not metamorphosed sediments or in any way comparable to the gondite series of the Central Provinces, but are altered phases of the hornblendic rocks, the alterations being brought about by the contact metamorphism of acidic intrusions and subsequent metasomatic or meteoric changes.[27] As, however, he applied a similar origin to the calc-granulites of the Sausar series which he saw at Utekata, about the sedimentary origin of which there is now not the slightest doubt, his conclusions regarding the rocks at Sakarsanhalli may be questioned. However,

[20] *Rec. Geol. Surv. Ind.*, 1886, **19**, 98.

[21] *Proc. As. Soc. Beng.*, 1917, **13**, cxcviii.

[22] *Rec. Mysore Geol. Dep.*, 1922, **21**, 186; *op. cit.*, 1924, **23**, 128; and *op. cit.*, 1925, **24**, 144-147.

[23] *Proc. Seventh Ind. Sci. Congr.*, 1921, cxv.

[24] *Rec. Geol. Surv. Ind.*, 1934, **68**, pp. 24-25.

[25] *Op. cit.*, 1926, **59**, 92.

[26] *Rec. Mysore Geol. Dep.*, 1923, **22**, pt. 2, 35.

[27] *Op. cit.*, 1931, **30**, 14-18.

in a very recent paper by M. B. Ramachandra Rao and K. Sripada Rao on the origin and correlation of these rocks, the same conclusion is reached that they are altered phases of the hornblende-schists of the lower division of the Dharwars and not metamorphosed sediments.[28] For the time being, then, the origin of these rocks must remain uncertain, though it is evident that they are very similar lithologically to parts of the Sausar series.

CORRELATION.

A condensed statement of the Archæan rocks in different parts of India has been given by J. A. Dunn.[29] This is of value in drawing attention to the difficulties of the problem, but his final table of correlation probably requires modification. For reasons given at the beginning of this article, it is impossible at present to correlate the Archæan rocks of the various tracts in India. But certain lines along which this may ultimately be accomplished are becoming clearer, and may be referred to briefly here.

Dr. Fermor has advanced the view that the manganese ores in the Archæan rocks of India are likely to be all of one age, and he has accordingly suggested that all Archæan rocks which contain syngenetic manganese should be taken to be of the same age, especially if they are associated with crystalline marbles, as in the Central Provinces.[30] The correlation of the Sausar series in the Central Provinces with the Gangpur series in Bihar and Orissa is a natural consequence of this hypothesis. Further, he has suggested that the Iron-ore series of Bihar and Orissa may be the same as the Sakoli series in the Central Provinces, both containing hæmatite rocks, and both being devoid of marbles.[31] At any rate it seems safe to suggest that the Sausar series and Sakoli series are together equivalent to the Gangpur series and Iron-ore series.

As regards the other Archæan tracts in India, it has already been indicated that the Aravallis of Rajputana and the Champaners of Bombay are lithologically similar to the Dharwars of South India, and it is possible that the two are continuous beneath the Deccan Trap of the Bombay Presidency. Thus, viewed broadly, we seem to have two belts of Archæan sedimentary rocks in India, within each of which the rocks can be roughly correlated; the Aravalli-Champaner-Dharwar belt, with a meridional extension, and the Central Provinces-Bihar and Orissa belt, with an equatorial extension. The difficulty arises when we try to find some common factor between these two belts which may be of correlative value. If we try to correlate the Sausar series of the Central Provinces with one of the three metamorphosed sedimentary systems in Rajputana on lithological grounds, it seems clear that they bear most resemblance to the Delhi system, with its calc-gneisses, mica-schists and quartzites. But the fact that manganese occurs in the Champaner series, which is the same as the Aravalli system, suggests, as Dr. Fermor has pointed out, a correlation of the Sausar series with the Aravallis, though the two are not particularly alike lithologically.[32] This separation of the Archæan tracts into two belts on structural and lithological grounds should not be allowed to obscure the probability of the Aravalli strike in south-east Rajputana curving round so as to join up with the E.-W. strike of the Central Provinces. The completed mapping of the older rocks of Rajputana shows that in the south the strike splays out to the south and to south-east before it plunges beneath the later Deccan Trap, as a glance at the new geological map of India will show. And it is quite possible that the south-eastern wing continues on beneath the Deccan Trap towards the Archæan rocks of the Central Provinces. It is true that some of the manganese in the Champaners may not be of syngenetic origin; but the occurrence of manganese ore of true gonditic affinities in Aravalli phyllites in Jhabua State certainly suggests an affinity between the Sausar series and the Aravalli system. The only alternative is the possibility that there are two horizons of manganese in the Archæan rocks of India, which Dr. Fermor thinks unlikely. As a possible means of correlation between the Central Provinces and South India, the manganiferous rocks at Sakarsanhalli, in Mysore State, have already been referred to. But the present uncertainty as to their origin makes their value for purposes of correlation rather doubtful. The only other similarity that one can point to between the rocks of the two belts is the lithological resemblance between the Older

[28] *Bull. Mysore Geol. Dep.*, 1934, No. 14.
[29] *Aust. Assn. Adv. Sci.*, 1926, **18**, 291.
[30] *Rec. Geol. Surv. Ind.*, 1926, **59**, 80.
[31] *Op. cit.*, 1933, **67**, 65.
[32] *Op. cit.*, 1934, **68**, 26.

Metamorphic series of Bihar and Orissa and the Dharwars of South India. This correlation, however, introduces several difficulties.

Finally, considering broadly the ancient metamorphic rocks of Rajputana, it will be found that they differ from those in other parts of India in two main respects. (1) They include a basal gneissic complex, upon which the metamorphosed sedimentary rocks rest unconformably, in contrast to other Archæan tracts in India where the ortho-gneisses have in every case been proved to be younger than the sedimentary schists. (2) They include three or four distinct systems of rocks separated by marked unconformities. This fact has led Heron to believe that the Delhi system is a post-Archæan formation.[33] The high degree of metamorphism and folding to which the Delhi rocks have been subjected is regarded as a phenomenon which was peculiar to Rajputana at so late a stage in pre-Cambrian times. On this assumption there are two alternatives.

(1) That the Delhis were roughly contemporaneous with the Cuddapahs, and that, as Heron has put it:

> 'They owe their folding and the related intrusion of granite batholiths to a special local upheaval in Rajputana which did not affect the rest of India, or to local persistence of disturbance in Rajputana after it had almost died out elsewhere.'

(2) That the Delhis are older than the Cuddapahs, but have no equivalents in other parts of India.

This is probably about as far as one can safely go at present with regard to correlation. But the advances which have been made in our knowledge of the Archæan rocks of India during the past ten or twelve years have been so considerable, that one may be fairly hopeful as to the eventual solution of many of the problems which today seem so puzzling. Dr. Fermor is believed to be reviewing the Archæan rocks of India in a comprehensive manner. The publication of his conclusions, based as they are upon an exceptional experience of the Archæan rocks of most parts of India, will be looked forward to with great interest.

In the accompanying table, summarising the classification of the older rocks in the four chief tracts in India that have so far been studied in detail, no correlation is intended between one area and another.

Rajputana	Central Provinces
Delhi system	Ortho-gneisses
Raialo series	Sakoli series
Aravalli system	Sausar series
Bundelkhand gneiss and Gneissic complex	
Bihar and Orissa	**South India**
Granitic rocks	Cuddapah system
Iron-ore series	Ortho-gneisses
Gangpur series	Dharwar system
Older metamorphics	

[33] *Mem. Geol. Surv. Ind.*, 1917, **45**, pt. 1, pp. 110-116.

Technological Researches at the University of the Punjab.

IN recognition of the valuable researches of basic importance to the Petroleum Industry conducted by Dr. S. S. Bhatnagar, Director, Punjab University Chemical Laboratories, Messrs. Steel Brothers Company Ltd., Agents, Indo-Burma and the Attock Oil Company, Ltd., have placed at the disposal of Prof. Bhatnagar, a sum of 1½ lakhs of rupees for research work on Petroleum and Allied subjects which will be paid in equal instalments over a period of five years. Messrs. Millar and Ward, Agents of Messrs. Steel Brothers, made a lumpsum grant to Prof. Bhatnagar as a personal gift, but the Professor offered to place the money at the disposal of the Punjab University, an offer which was thankfully accepted, with a view to inaugurating a department of Petroleum Research under his guidance.

One of the features of the scheme is that all results of a patentable nature will be exploited jointly by Messrs. Steel Brothers and Prof. Bhatnagar and/or his chemists and the profits will be shared equally between the Company and the parties concerned. Dr. Bhatnagar proposes to give the University a large share of his profits for the furtherance of scientific, industrial and medical research in the University.

Intra-Molecular Rotation in Organic Compounds.

By M. A. Govinda Rau, M.A., Ph.D.

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AMONG the movements that the atoms can perform inside a molecule, that which is of special interest to the organic chemist is the so-called "inner rotation," *i.e.*, the rotation of molecular parts about each other. The degree of this internal freedom is also of great significance in the study of the physical properties of molecules, such as dipole moments and specific heats: thus in any quantitative calculation of the specific heat of a molecule from the data on the fundamental oscillation frequencies provided by Raman spectra, the degree of internal rotation must also be taken into consideration. It was one of the fundamental assumptions in organic chemistry that atomic groups bound by double or triple bonds could not rotate about each other, but when they were joined by only a single bond a free rotation should be expected. The limitations of this concept have been made evident from two typical investigations. L. Ebert[1] has shown that *cis* and *trans* ethylene isomers can change each into the other at temperatures not by any means high, and reach an equilibrium state. On the other hand, by the resolution of diphenyl derivatives containing two or more substituents in the 2 2′6 6′ positions, into optical antipodes by Mills, Adams and others,[2] it has been shown that the rotation about a single bond is not always free, but can be strongly restricted through the influence of substituents. The point is thus clear that rotation about any bond is a possibility and that rotation about each type of bond can be restricted to different extents according to the conditions prevailing inside the molecule. In recent years* the mathematics of quantum and wave mechanics have been applied to this problem by Mullikan,[3] Slater,[4] Pauling,[5] Hückel,[6] Dunkel,[7] Penney,[8] and Penney and Sutherland.[9] Summary reviews of this subject from special points of view have also been very recently published.[10]

The causes for restriction of rotation can be classified into (*a*) steric forces, (*b*) multiple bonds, and (*c*) energy troughs. In general the mechanism for the restriction of rotation is that the potential energy between the rotating parts of the molecule is not independent of the angle of rotation, but changes with it. Let us take a simple case where the potential energy-angle of rotation curve has the shape shown in Fig. 1

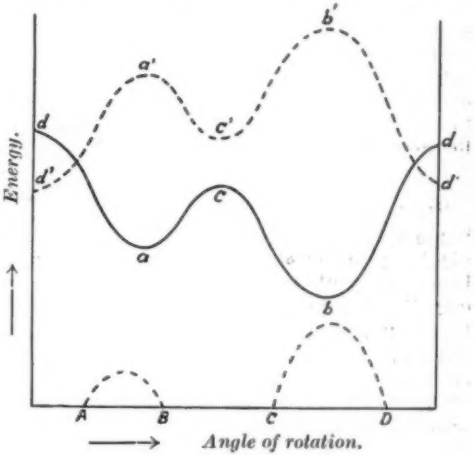

Fig. 1.

(*d a c b d*), with two energy minima *a* and *b*. At a particular high temperature, the kinetic energy of the rotating parts of the molecule can be represented by the dotted line *d′ a′ c′ b′ d′*. Such a line will have a maximum where the potential energy has a minimum, and represents a fully developed rotation. When the temperature is reduced the line of kinetic energy will sink,

[1] L. Ebert and R. Bull, *Z. Physikal Ch.* (A), 1931, **152**, 451.

[2] R. Adams, *Chemical Rev.*, 1933, **12**, 261.

* One of the earliest attempts at a quantitative interpretation of intra-molecular rotation seems to be that of H. Sachse, *Z. Physikal Ch.*, 1893, **11**, 185.

[3] R. Mullikan, *Phys. Rev.*, 1933, **43**, 279.

[4] J. C. Slater, *Ibid.*, 1931, **37**, 481.

[5] L. Pauling, *J. Amer. Chem. Soc.*, 1931, **53**, 1367.

[6] E. Hückel, *Z. Physik.*, 1930, **60**, 423.

[7] M. Dunkel, *Z. Physikal Ch.* (B), 1930, **7**, 81.

[8] W. G. Penney, *Proc. Roy. Soc.*, 1934, **144**, 166; *Proc. Phys. Soc.*, 1934, **46**, 333.

[9] W. G. Penney and G. B. B. M. Sutherland, *J. Chem. Phys.*, 1934, **2**, 492.

[10] P. C. Henriquez, *Chem. Weekblad.*, 1934, **31**, 2. E. Hertel, *Z. Elektrochem.*, 1934, **40**, 405. H. Mark, *Ibid.*, 1934, **40**, 421.

and at some low temperature there will be points where the kinetic energy is zero (A, B, C and D). The rotation is then no more fully developed, and the points A, B, C and D represent inversion points. There will be now only oscillations about the minima *a* and *b*. As all the molecules do not have the same "temperature" at any instant of time, there will be a mixture of molecules with small oscillations, with large oscillations, and with fully developed rotation. The intra-molecular rotations will be quantised. The lower the temperature becomes the more the molecules with small oscillations will predominate; quantitatively this can be expressed by the Maxwell-Boltzmann law of distribution. If the average oscillations about *a* and *b* are very small, we can speak of two isomers, "rotation isomers", the one characterised by the minimum *a* and the other by the minimum *b*. The velocity with which these isomers can pass into one another is determined by the energy levels *c* and *d*, and the equilibrium between them by the energy difference ΔU between *a* and *b*.

STERIC FORCES.

Steric force is a better and more precise name given to the organic chemist's mechanical concept of steric hindrance. From a large amount of systematic and semi-quantitative work,[2] chemists have come to the conclusion that in ortho-substituted diphenyl derivatives, the rotation of the two benzene rings is restricted not by the number but by the size of the substituents. The dipole moments of a series of simple di-substituted diphenyl derivatives have been recently measured[11] in order to study quantitatively the nature and degree of restriction of rotation. Weissberger[12] believes that London forces of attraction between substituents even though of the same sign, come into play when they are near enough together, and thus contribute to the restriction of rotation. The question, however, is complicated on account of the still unknown nature of electronic shifts from one ring to the other. The existence of yet another reason for the reduction of freedom of rotation in the diphenyls will be referred to later.

Another case of restriction of free rotation by steric forces is to be found in compounds of the type $C\alpha_4$, where α is a non-axial symmetric substituent of the type CH_2OH, OC_2H_5, CH_2ONO_2, CH_2Br, etc. If a complete free rotation of such substituents about the four tetrahedral valencies of the central carbon atom were possible, then the moment of the molecule will not be zero but will have a definite value[13] given by $\sqrt{4\mu^2_k} = 2\mu_k$ where μ_k is the component of the group moment perpendicular to the axis of rotation. However since some of the compounds like $C(CH_2Br)_4$ have zero moment, and the moments of the other compounds do not change with temperature, it is generally concluded that due to lack of space for complete rotation or to the high intra-molecular fields, the groups in these molecules do not freely rotate but take up definite oriented positions.[14]

It would appear that free rotation is also annulled in the crystal state. The magnetic susceptibility measurements of Krishnan[15] and X-ray studies of Hertel[16] have shown that in di-, ter- and quater-phenyls, the benzene rings all lie in one line fixed in definite relative positions in the same plane. This phenomenon of fixing the rings in the crystal state shows interesting possibilities.[17] Thus, *m m'* diphenyl, although it cannot occur as stable *cis* and *trans* isomers can be fixed by suitably crystallising the substance in these two isomeric forms. Probably on account of the still feeble forces between the two *m m'* substituents a *trans* form will be more exclusively obtained; but a 3 3′ 5 5′ tetra substituted compound should be capable of being more easily fixed in the two isomeric forms. Such an isomerism would belong to the type called "crystal lattice isomerism", that has been particularly studied by Hertel[18] and others in a different case of inter-molecular compounds.

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[11] A. Weissberger and S. Sangewald, *Z. Physikal Ch.* (B), 1933, **20**, 145; *Trans. Farad. Soc.*, 1934, **30**, 884.
E. Naeshagen, *Z. Physikal Ch.* (B), 1934, **25**, 157.

[12] A. Weissberger, *Trans. Farad. Soc.*, 1934, **30**, 852.

[13] W. Hückel, *Z. Physikal Ch.* (B), 1929, **2**, 451.
C. T. Zahn, *Physical Z.*, 1932, **33**, 400.

[14] L. Ebert, *Leipziger Vortrage*, 1929, 65.

[15] K. S. Krishnan, B. C. Guha, and S. Banerjee, *Phil. Trans. Roy. Soc.* (A), 1933, **231**, 235.

[16] E. Hertel and G. H. Romer, *Z. Physikal Ch.* (B), 1933, **21**, 292; **23**, 226.

[17] E. Hertel, *Z. Elektrochem.*, 1934, **40**, 407.

[18] E. Hertel, *Z. Elektrochem.*, 1931, **37**, 536.
E. Hertel and G. H. Romer, Z, *Physikal Ch.* (B), 1932, **19**, 288.

Interesting in this connection is the problem of restricted rotation about a single bond in a closed ring which does not seem to have been submitted to theoretical or otherwise quantitative investigations. Sachse[19], and Mohr[20] have postulated a restricted rotation in the cyclohexane ring so that an alternation between the *cis* and *trans* forms of this compound is possible. From his electron interference measurements Wierl[21] concludes that cyclohexane is an equilibrium mixture of the *cis* and *trans*, or what are more picturesquely called boat and chair forms. The measurements by O. Hassel[22] of the dipole moments of cyclohexane derivatives have yielded no definite conclusions. Le Fevre,[22] however, regards that the observed moment of 1 : 4 cyclohexadione is in agreement with a dynamic equilibrium between the *cis* and *trans* forms: and K. L. Wolf[23] has sought to explain the very high negative Kerr constant (–713) of paraldehyde on the basis of the *cis* and *trans* forms of the molecule.

MULTIPLE BONDS.

The power of the double bond between carbon and carbon, or carbon and nitrogen to completely hinder free rotation about it so that only two stable equilibrium positions exist *cis* and *trans*, or *syn* and *anti*, is well known. The precise electronic mechanism which prevents the free rotation about the double bond has been worked out by Mullikan,[3] Hückel[6] and Penney[8]. However, on account of the considerable polarisability of the double bond compared to a single bond, this restricting power of the double bond is susceptible to strong modifications by the presence of substituents. The power for each specific case can be expressed in the shape of a potential energy-angle of rotation curve, which will have a form shown in Fig. 2 with two deep and sharp minima 180° apart. The height of the energy barrier between them could be calculated theoretically for some simple cases,[8] or derived from various physical measurements. Thus from a study of reaction kinetics, in the case of the fumaric and maleic acids Höjendahl[24] found a value of 15·8 k. cal. per mol. and in the case of dimethyl maleate and fumarate

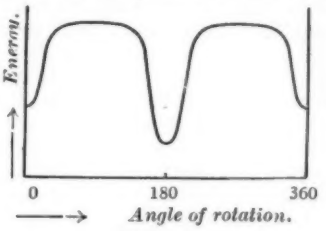

Fig. 2.

Nelles and Kistiakowsky[25] found a value 26·5 k. cal. Again from the fundamental twisting frequency for ethylene[26] the value of the energy barrier between the *cis* and *trans* forms could be estimated[27] to be about 30 k. cal. Ebert and Bull[28] find that at a temperature of 300°C., this energy barrier could be crossed over in the case of the symmetrical dichlor ethylenes. It was also observed that the *cis* form was the more stable of the two, the equilibrium mixture at this temperature consisting of 65% *cis* and 35% *trans*, and the energy difference between the two was estimated as 530 cal./mol. Although this result is contrary to what one would expect from the dipole forces alone, when other influences are taken into consideration[29] such as the London attraction (dispersion effect) between the substituent atoms, and the polarisation of the double bond by the strong field density produced by them in the *cis* position (induction effect), it could be shown that the observations stand theoretically supported. In as much as the induction effect on the double bond for the *cis* compound is very pronounced, it will be interesting to co-relate this with the observed[30] differences in the intensity and magnitude of the C=C frequencies given by the Raman spectra of these two isomers.

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[19] H. Sachse, *Z. Physikal Ch.*, 1892, **10**, 203; *Ber.*, 1890, **23**, 1365.

[20] E. Mohr, *J. Praktisch Ch.*, 1918, **98**, 315.

[21] R. Wierl, *Ann. der Physik.*, 1931, **8**, 559; 1932, **13**, 453.

[22] O. Hassel, *Trans. Farad. Soc.*, 1934, **30**, 876. R. J. W. Le Févre, *Ibid.*, p. 874.

[23] K. L. Wolf, *Leip. Vortrage*, 1929, 129.

[24] K. Höjendahl, *Z. Phys. Chem.*, 1924, **28**, 758.

[25] M. Nelles and G. B. Kistiakowsky, *J. Amer. Chem. Soc.*, 1932, **54**, 2208; *Z. Physikal Chem.*, 1931, Bodenstein Band, 369.

[26] A. Eucken and A. Parts, *Z. Physikal Ch.* (B), 1933, **20**, 192.

[27] W. G. Penney, *Proc. Phys. Soc.*, 1934, **46**, 333.

[28] L. Ebert and R. Bull, *Z. Physikal Ch.* (A), 1931, **152**, 451.

[29] H. A. Stuart, *Physikal Z.*, 1931, **32**, 793.

[30] Bonino and Brul, *Z. Phys.*, 1929, **58**, 194. M. Pestemer, *Wiener Ber.*, IIA, 1930, **139**, 667.

ENERGY TROUGHS.

In contrast to the double bond the charge distribution in a single bond has a rotation symmetry, and a completely unhindered free rotation should be expected provided there is no interaction between the substituents or between the substituents and the carbon atoms. This ideal case is almost non-existent in the whole field of organic chemistry. Thus Penney[8] has shown that even in the simpiest case of ethane, both by the H-L-P-S, and H-M methods of approximation, there will be free rotation of the CH_3 groups around the C-C axis *only* if the interactions of any H atom with the distant C and H atoms are neglected. When, however, the H-H interactions are allowed for, the azimuth ϕ around the C-C axis of one CH_3 group with respect to the other will appear implicitly in the H-H exchange integrals, and the energy will be no more independent of ϕ. The general form of the energy curve can have a number of maxima and minima or energy troughs. Koenig[31] has considered the dynamics of a very general case where the potential field has n maxima and minima in the range $0 \leqslant \phi \leqslant 2\pi$; and, Eyring[32] has calculated the complete shape of the curve for the case of ethane, and finds three maxima corresponding to three paired hydrogen positions and the accompanying three minima corresponding to the *trans* positions of the hydrogen atoms. The separating energy wall is only 350 cal./mol. so that at room temperature, where the mean energy RT ~ 600 cal./mol. the molecule can go from one trough to another and execute a complete rotation. But if the temperature is lowered this should be no more possible, and the molecule can perform only oscillations about the energy minima. Eucken and Weigert[33] have been actually able to show from measurements of molar heat over a large range of temperatures down to 143°T, that at low temperatures ethane behaves as a restricted one dimensional rotator, performing only oscillations about a minimum energy point. If a complete free rotation were possible then at these low temperatures, where the other inner degrees of freedom are not yet developed, the specific heat should be 6+1=7 calories, while actually it is of the order 7·4: this excess is due to the oscillatory motion which has two degrees of freedom one for the potential energy and another for the kinetic energy. By a simultaneous comparison with the specific heat of ethylene, where there is no inner rotation possible, the increase in specific heat over a free rotating model can be quantitatively accounted for if the potential energy barrier is taken as 350 cal./mol. a value which agrees beautifully with that calculated by Eyring. At room temperatures only about 50% of the molecules have any inner rotation, and among them 45% have quantum number 1 (*i.e.*, oscillation) and 5% quantum number 2 (*i.e.*, free rotation).

In the case of substituted ethanes, the energy curve will be more complicated, the energy minima being of different depths and occupying different positions. An instance where this curve has been worked out in some detail is that of symmetrical dichlorethane.[34] The calculated relation between the distribution of the molecule into its various energy levels, and the effective dipole moment at different temperatures,[35] has been substantiated by careful experimental work,[36] and *vice versa*, from the experimental values of moment, the magnitude of the intra-molecular forces have been estimated. A considerable volume of work has been turned out regarding the possible degrees of rotation inside molecules and their bearing on the observed dipole moments, ever since the first papers on this subject were published by Höjendahl and Williams.[37]

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[31] H. D. Koenig, *Phys. Rev.*, 1933, **44**, 657.

[32] H. Eyring, *J. Amer. Chem. Soc.*, 1932, **54**, 3191.

[33] A. Eucken and K. Weigert, *Z. Physikal Ch.* (B), 1933, **23**, 265.
C. Wagner. *Ibid.* (B), 1931, **14**, 166.
L. Ebert, *Leip. Vortrage*, 1929, **44**.

[34] E. H. L. Meyer, *Z. Physikal Ch.* (B), 1930, **8**, 27.
C. P. Smyth, R. W. Dornte and E. B. Wilson, *J. Am. Chem. Soc.*, 1931, **53**, 4242.

[35] S. Mizushima and K. Higashi, *Proc. Imp. Acad., Tokyo*, 1932, **8**, 482.
J. E. Lennard Jones and H. H. M. Pike, *Trans. Farad. Soc.*, 1934, **30**, 830.
J. M. Sturtevant, *J. Am. Chem. Soc.*, 1933, **55**, 4178.

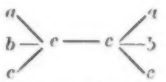
[36] E. W. Greene and J. W. Williams, *Phys. Rev.*, 1932, **42**, 119.
M. A. Govinda Rau and B. N. Narayanaswamy, *Proc. Ind. Acad. Sci.*, 1934, **1**, 14.
S. Mizushima and K. Higashi, *loc. cit.*

[37] J. W. Williams, *Z. Physikal Ch.*, 1928, **138**, 75.
K. Höjendahl, *Physical Z.*, 1929, **30**, 391.
C. T. Zahn, *Ibid*, 1932, **33**, 400, 529, 730, 1933, **34**, 570.
C. P. Smyth and S. E. Kammerling, *J. Am. Chem. Soc.*, 1931, **53**, 2988.
P. C. Henriquez, *loc. cit.*

The existence of oscillations about a position of minimum energy has also been substantiated by X-ray interference diagrams.[38] Evidences for such positions of minimum energy seem also to be obtained from the Raman spectra of a number of molecules, and are neatly marshalled out in one of Kohlrausch's recent reviews.[39] However, the possibilities of these physical measurements to yield more quantitative informations regarding the intra-molecular rotation, have not been completely investigated.

When the two rotating parts are sufficiently separated as by introducing a benzene ring between them, the energy barriers can be smoothed down, and complete rotations made possible: such instances are to be found in *p*-xylylene dichloride, *p*-quinone dimethyl ether, etc.[40]

If there are more than one substituent in each of the methyl groups of ethane, there will be in general three pronounced energy minima, with appreciable energy barriers, and at low temperatures there will be a mixture of three rotation isomers, characterised by three equilibrium positions. Wolf[41] has shown that such rotation isomers exist in the case of tartaric acid and dibenzyl derivatives, which are symmetrically substituted ethane compounds of the type



In the meso form of these compounds the substituents *a*, *b* and *c* are so placed that all three can simultaneously occur in the *cis* or *trans* positions, while in the optically active form they cannot do so. If a complete free rotation were possible about the C–C link, both forms of the molecule will have identical moment. As this is not the case, and the active form has in general a higher moment (at the ordinary temperatures) than the meso form, it is obvious that in the latter the molecule tends to get fixed more in the completely *trans* position. Thus at T=0, the meso form will be fixed in this position, and the moment will be zero, while for the active form the moment will be a finite value—(since all *trans* positions cannot simultaneously occur). As the temperature is increased, on account of the fact that in the meso all the *cis* positions are simultaneously possible, the moment will reach a higher maximum than the *cis*, and the two curves representing moment *vs.* temperature will be separate and cross each other at some particular point. If we regard each form to consist of three isomers in equilibrium, with different optical rotations, then as the temperature rises the ratios between the isomers will shift and thus also the total optical rotation. Now, Lucas[42] has shown that in order that the rotation *vs.* temperature curve should have a maximum there should be at least three isomers present. In the case of ethyl tartrate an actual maximum has been observed. Further measurements on change of rotation with concentration also support the existence of three isomers. These evidences are, however, not altogether quantitative, as the influence of solvent, etc., have also to be taken into consideration.

Recent ideas regarding several possible canonical structures for one and the same molecule existing in a state of quantum mechanical resonance[43] have raised interesting possibilities, as certain bonds which are single in the ordinary structures are double in some others and thus acquire in part the properties of a double bond and *vice versa*. Problems connected with this have been recently discussed by Sutton[44] and Zahn[45]. Sidgwick[46] has, however, questioned the validity of some of the assumptions made although they may be mathematically correct. Another result of the resonance or the interference between the electronic clouds of a pair of singly linked atoms is the possibility of preferred angular positions, such as the highly unsymmetrical skew structures postulated by Penney and Sutherland[27] for H_2O_2 and N_2H_4.

An interesting possibility of the intra-molecular rotation is the resulting shape of long chain molecules containing a series of C—C links. If there are two dipoles, each of moment *m*, at the two ends, one end

[38] F. Erhardt, *Physikal Z.*, 1932, **33**, 605.

[39] K. W. F. Kohlrausch, *Naturwiss.*, 1934, **22**, 166. *Z. Physikal Ch.* (B), 1932, **18**, 61.

[40] A. Weissberger and R. Sangewald, *Physikal Z.*, 1929, **30**, 792.

[41] K. L. Wolf and W. Bodenheimer, *Zeit. Physik. Chem.*, 1931, Bodenstein band, 620.

[42] R. Lucas, *Trans. Farad. Soc.*, 1930, **26**, 418.

[43] L. Pauling and J. Sherman, *J. Chem. Physics*, 1933, **1**, 606, 679.

[44] L. E. Sutton, *Trans. Farad. Soc.*, 1934, **30**, 789.

[45] C. T Zahn, *Ibid.*, 1934, **30**, 804.

[46] N. V. Sidgwick, *Ibid.*, 1934, **30**, 821.

moment can set itself in any direction independent of the other, and the resulting moment of the molecule will be $\sqrt{2}\,m$ irrespective of the number of links above a certain limit. This has been experimentally observed.[47] Recently Kuhn[48] has calculated the shape of such molecules to be that of a bean the ratio of whose axes are 6 : 2·3 : 1. Further the electron interference measurements with 1,5-dichlorpentane[49] show that in this case the distance between the end chlorine atoms cannot be defined.

Much of the above review shows how general is the phenomenon of intra-molecular rotation and how our ideas about it are still very qualitative. There is certainly ample scope for precise and quantitative investigations in this field.

Study of Plant Tissue Fluids.*

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Indian Institute of Science, Bangalore.

Chemical Investigations.

A CHEMICAL study of the plant sap usually consists of a proximate analysis of the more important constituents, like total solids, total ash, total and amino nitrogens, sugars and ash constituents particularly P, K and Ca. In special cases, a determination of some definite constituent pertinent to the investigation, is carried out. In a study of the nature of rust resistance in wheat, Newton and Anderson[114] have determined the phenol content in the press juice of wheat plants varying in rust resistance. Link and others[115] have determined protocatechuric acid in the pigmented variety of onions, which is reputed to resist the fungus disease known as the onion smudge. Power and Chesnut[116] have examined the odorous constituents of the cotton plant, ammonia and trimethyl amine as the possible attractants of the boll-worm. Those varieties of cotton whose content of these constituents is low, are the ones more resistant to the attack of the boll-worm.

For most of the routine estimations, the centrifuged sap can be directly employed but for the estimation of certain constituents like sugars, phenols, a suitable method of clarification has to be adopted, with a view to eliminate substances interfering with the reaction. Immiscible solvents like ether or chloroform can be employed for extracting the constituent from the sap; sometimes a preliminary separation of the associated impurities by precipitating them out with a miscible solvent like alcohol or acetone facilitates subsequent processes of purification. This is elegantly achieved by absorbing the sap on a filter pad or pulp[117] and extracting the impregnated mass with alcohol or acetone.

There are other physical methods of fractionating the sap into groups of constituents, which are helpful in the isolation of certain constituents; ultra-filtration, for example, will effect a separation of the sap roughly into two portions, the filtrate containing mostly the crystalloidal constituents of the tissue fluid. The advantage of such a fractionation lies in the fact that both the ultra-filtrate and the residue are obtained in a "pure" state without any admixture of adsorbents, solvents or salts. Electro-ultra-filtration also can be employed with advantage in many instances, to ensure a greater rapidity of separation. The application of such colloid chemical technique has not been extensively employed in a study of the plant tissue fluids.

A line of investigation which has received little attention is the assay of the tissue fluids from the viewpoint of its dynamic nature. It is determined by the presence of the reactive groups on the one hand, and the agents catalysing certain reactions on the other. The reactive groups, aldehydic, ketonic, amino, sulphydryl, hydroxyl, phenolic, carboxyl, can easily be estimated chemically while the existence of the biochemical catalysts present in the fluid is

[47] L. Ebert and K. Höjendahl, *Z. Physikal Ch.* (B), 1932, **15**, 74.

[48] W. Kuhn, *Koll. Z.*, 1934, **68**, 2.

* Continued from *Curr. Sci.* 1934, **3**, 58.

[114] Newton and Anderson, *Can. J. Res.*, 1929, **1**, 85.

[115] Link *et al*, *J. Biol. Chem.*, 1929, **81**, 369.

[116] Power and Chesnut, *J. Amer. Chem. Soc.*, 1925, **47**, 1751.

[49] R. Wierl, *Ann. der Phys.*, 1931, **8**, 521.

[117] Sreenivasaya and Sastri, *J.C.S., abst.*, 1931, **A**, 1342.

revealed through a study of the enzyme make up of the sap.[118 119]

COLLOID CHEMICAL INVESTIGATIONS.

Colloid chemical studies of plant tissue fluids open out a new field of investigation. The most comprehensive investigation which has been conducted is in connection with the study of drought resistance[52] and winter hardiness[6, 53, 54, 55] in plants. Particular attention should be drawn to the systematic work of Gortner, Newton and others in the field. Newton[120] has studied the gold number of colloids in plant tissue fluids in the course of dialysis. The question of hydration of colloids in plant juices is a problem which has aroused wide interest in the field of plant physiology and this important and extensive subject should be dealt with in a separate review.

The Origin of the Santra Orange.

By S. S. Bhat, M.Ag.

THE *Santra* orange is perhaps the most important table variety of citrus in India, its cultivation being chiefly concentrated in the Central Provinces and parts of Western India—more than 10,000 acres being under its cultivation in these tracts. It is a loose-skinned orange of the Tangarin type, and was for a long time accepted in this country as *Citrus aurantium*. The description of King orange (*Citrus nobilis*) of California seems to agree well with that of *Santra*. As there are other types of loose-skinned oranges like *Ladu* and *Kavla* growing in this country and closely related to *Santra*, it is difficult to say which of them is exactly the King orange. After a careful study of the various systems of classification of citrus fruits offered by different authors, Cheema and Bhat[1] have assigned to *Santra* the place and name of *Citrus nobilis*, Lour. var. *deliciosa* Swingle.

Like the other varieties of citrus, the *Santra* seems to have originated somewhere in Southern and Cochin China. Citrus varieties are even at present found in a wild state also at the foot of the Himalayas in the north-eastern part of India.[2] There are references to these fruits in the ancient Sanskrit literature. The very word *Santra* might have been derived from the Sanskrit word *sam* (सम्) meaning 'well', and *tri* (तृ) meaning, 'to float', the whole word '*Santra*' meaning one that floats well. The fruit floats very well indeed in water. The fruits were possibly observed coming to the southern parts floating in rivers from the wilds at the foot of the Himalayas. Hence the name *Santra* or the floating fruit seems to have been given to it in the earliest times as soon as it came to the notice of the ancient Sanskrit-knowing Aryans. The other word *Narangi*, which is another popular name of this fruit, is perhaps similarly derived. *Narangi* is a corruption of the word "Nagaranga" (नागरंग). *Naga* means red lead in Sanskrit. *Arangama* or *aranga* means one that becomes visible. Both these words on joining form the word *nagaranga*, and mean one that has the red lead colour and that becomes visible or floats. Both the words *santra* and *nagaranga* or *narangi* are descriptive. The application of descriptive words to objects in Sanskrit is almost universally traditional as in Latin. Further, names of oranges in the original Khasi languages are words like *Usoh niamtra*, *Usoh sim*, *Usoh mianger*, etc. These words do not seem to bear any relation to the word *santra*. However, it is perhaps possible to derive the word *santra* from the word *Usoh niamtra*. If the first letters of these two syllables '*U*' and '*ni*' are dropped, what remains comes to be '*soh*' and '*amtra*'. Now joining these two latter syllables, a word like '*sohamtra*', '*sontra*' or '*santra*' may be formed. Excepting this very doubtful likelihood, it seems, therefore, more probable that the word *santra* must have been a name given to the fruit by the Sanskrit-knowing Aryans. Bonavia suggests the derivation of the word *santra* from the word *Shans*, who were rulers in Assam about the beginning of the Christian era. This

[118] Sastri and Sreenivasaya, *Enzymes of the sandal leaf in health and disease* (unpublished).

[119] Votchel, *C.A.*, 1924, **18**, 2359.

[1] Cheema, G. S., and Bhat, S. S., "A Study of the Citrus varieties of the Bombay Presidency", *Curr. Sci.*, 1934, **2**, 8, 298–304.

[2] Bonavia, E., "The cultivated oranges and lemons of India and Ceylon."

[120] Newton and Martin, *Can. J. Res.*, 1930, **3**, 336.

suggestion fits in well so far as the first part '*san*' is concerned. But how a syllable like '*tra*' came to be affixed is not at all explained. It seems therefore possible

(1) that these words *santra* and *narangi* were non-existing before the fruit was known to the Aryans. The Chinese and the Khasi languages have their own distinct vernacular names for these fruits;

(2) the fruit was existing in the north-eastern parts of India before the Aryans came there;

(3) the fruit must either be indigenous in the north-eastern parts of India, or it must have been introduced there from the neighbouring countries on the East, in prehistoric times.

Letters to the Editor.

Elimination of Bias due to Selection.

As correlation methods are being used now-a-days to a much greater extent than before for forecasting, say, the rainfall or temperature at any place or even the amount of wheat grown in any particular area, a problem, which is often overlooked by forecasters, has become somewhat important. The problem arises in the following manner.

When we want to select some factors for forecasting a quantity, we often take a number of factors, correlate each of them with our forecasted quantity and select out of these factors two or more factors which give the highest C.C. (written in short for correlation coefficient) with our forecasted quantity. In testing these selected C.C.'s for significance, some forecasters apply the usual tests for significance, overlooking the fact that these tests are meant only for C.C.'s selected at random and not for C.C.'s so deliberately chosen as these. In these latter cases Walker's test[1] has to be applied.

Now, all that Walker's test tells us is whether our selected C.C.'s could have been obtained by mere random chance from populations of which the C.C. ρ is zero. By "random chance" is meant here either Walker's level of significance, *viz.*, 50%, or the 5% level of significance suggested by R. A. Fisher. If the selected C.C.'s could not have been obtained by random chance from populations in which $\rho=0$, the C.C.'s are considered significant, and the selected factors are used to give a forecasting formula in the usual manner.

The forecaster is also very much interested to find out the approximate value of the C.C.'s of the various populations from which our selected C.C.'s are samples, in order to determine, at least qualitatively, the amount of reliance that he can place in his factors. For this purpose he will have to apply Normand's Performance Test.[2] Unfortunately he will have to wait for a number of years for the accumulation of data before he can use the Performance Test. As this Test is thus not of immediate use, a method has been discovered by which it is possible to eliminate the bias due to selection from each of the selected C.C.'s and thus get values which are the least values of the corresponding ρ's of the populations either on Walker's or Fisher's level of significance. Full details of the method are given in a paper which will be published elsewhere. Only a gist will be given here.

Let ρ be the C.C. of the population from which m random samples of n values each are drawn and let the C.C.'s be worked out for each sample. Suppose we select $(l+1)$ highest C.C.'s of which let the lowest value be r_1. Let p be the chance of obtaining a C.C. numerically less than r_1 in a random sample of n from the population. Then the chance of getting in the selected $(l+1)$ C.C.'s no C.C. which is numerically less than r_1, out of m random C.C.'s is given by

$$P = 1 - (p^m + {}_mC_1 p^{m-1}q + {}_mC_2 p^{m-2}q^2 + \cdots + {}_mC_l p^{m-l}q^l) \cdots \quad \text{I}$$

where $q = 1-p$.

Although equation I is of the mth degree, in p it has only one real positive fractional root, which may be called the probability root. We can obtain the probability roots after putting $P = 0{\cdot}5$ and $0{\cdot}05$ in I. Let these roots be denoted by p $(0{\cdot}5)$ and p $(0{\cdot}05)$ respectively. We can now find the value of ρ corresponding to p $(0{\cdot}5)$, r_1 and n. Let this value be denoted by ρ $(0{\cdot}5)$. Similarly we can find ρ $(0{\cdot}05)$. ρ $(0{\cdot}5)$ and ρ $(0{\cdot}05)$ are the *least* values of ρ's of the

[1] G. T. Walker, *Mem. Ind. Met. Dept.*, 1914, **21**, 13-15; S. R. Savur and S. Gopal Rau, *Ind. Met. Dept., Sci. Notes*, **5**, No. 49.

[2] C. W. B. Normand, *Q. J. R. Met. Soc.*, 1932, **58**, 3-10; S. R. Savur, *Ind. Jour. Phy.*, **7**, Part 1, pp. 27-34.

populations on the 50% and 5% level of significance respectively, which gave us $(l+1)$ C.C.'s which are not numerically less than r_1 in m random C.C.'s. These values will help the forecaster in forming a rough estimate of the amount of reliability he can place in his forecasts. As already mentioned above, more details will be given elsewhere.

S. R. SAVUR.

Meteorological Office,
Poona 5,
September 14, 1934.

Rectification Phenomenon in Pyrolusite Crystal.

IN the course of our investigations on the crystal-and-point rectification, we found that when ordinary mineral pyrolusite (MnO_2) crystal was dipped into mercury, alternating current was rectified to a great extent. The source of the alternating current was a 1000 cycle alternator (microphone hummer). When tested with steady voltages, the current-voltage characteristic curve showed a marked asymmetry. A typical characteristic curve is shown in Fig 1. The resistances as calculated from the curve for different positive and negative voltages are also illustrated in the same figure. The rectification ratio which is taken as the ratio of the difference of the currents in the two opposite directions to the larger value of the current is also shown. The ratio decreased in this particular experiment with the applied voltage. The value was 50% for 2 volts.

The mercury used was cleaned after shaking it with dilute nitric acid in a mechanically shaking machine for eight hours. After subsequently washing it in running distilled water, the pyrolusite crystal on drying was mounted so as to dip into the clean mercury. The crystals such as galena (PbS), iron pyrites (FeS_2), bornite (Cu_2S, CuS, FeS), magnetite (Fe_3O_4), molybdenite (MoS_2) did not, however, show any such rectification effect, when similar experiments were performed under similar conditions.

It should be made clear that the rectification generally observed with these crystals in combination with a pointed metal is reduced to zero, when the contact area is large. The pyrolusite crystal dipped into mercury had, in our experiments, a very large contact area so that the effect observed could not be attributed to the ordinary crystal-and-point rectification. When the same pyrolusite crystal was held between two electrodes of large area, there was no such rectification effect.

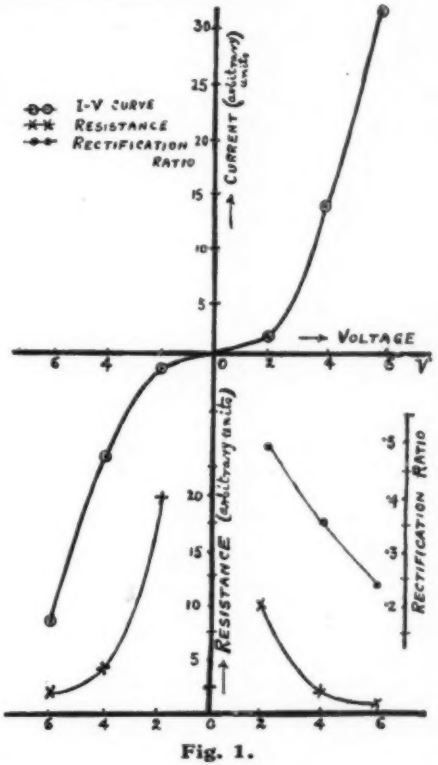

Fig. 1.

The cause of this rectification seems to be associated with the layer of air between the surface of the crystal and mercury. This is yet a subject of further investigation. Whatever be the cause, this promises to be of great practical use.

S. R. KHASTGIR.
ANIL KUMAR DAS GUPTA.

Physics Laboratory,
Dacca University,
September 23, 1934.

The Band Systems of $CaCl_2$.

THE spectrum of the carbon arc fed with $CaCl_2$ has been measured on plates taken in the first order of a 21 ft. grating. These data together with those of Hedfeld* are utilised in analysing the bands. While

* *Zeit. für. Phys.*, 1931, **68**, 610.

there is excellent agreement between the data of Hedfeld and the present measurements, some of the bands measured by him do not really belong to the $CaCl_2$ molecule.

The bands consist of two systems one of which, the red system, is clearly due to the transition $^2\Pi \rightarrow {}^2\Sigma$. These involve *two* P and *two* Q heads and the system comprises only the $\Delta v = 0$ and -1 sequences. The equation representing the Q_1 heads is:—

$$\nu = 16094{\cdot}6 + (363{\cdot}76\,v' - 1{\cdot}16\,v'^2 + 0{\cdot}0012\,v'^3) - (360{\cdot}81\,v'' - 1{\cdot}01v''^2 - 0{\cdot}001\,v''^3).$$

The heats of dissociation for the $^2\Pi$ and $^2\Sigma$ states are found to be 4·60 and 3·46 volts respectively. This indicates that in the $^2\Pi$ state of the molecule is involved the anomalous $(4p)^3\,{}^3P$ term of the Ca atom. The $^2\Sigma$ state arises out of the $(4s\,4p)\,{}^3P^\circ$ term of the Ca atom.

The other, orange system, involves evidently a $\Sigma - \Sigma$ transition. The final level of this system does not at all correspond to the final level of the red system. These bands degrade towards the shorter waves but the sequences degrade to the longer waves. Only two, $\Delta v = 0$ and $+1$ sequences are developed. The following equation represents the heads:—

$$\nu = 16847{\cdot}6 + (361{\cdot}38\,v' - 1{\cdot}68v'^2 - 0{\cdot}015v'^3) - (364{\cdot}51v'' - 1{\cdot}46\,v''^2 - 0{\cdot}02v''^3).$$

This gives for the heats of dissociation of the upper and lower states, 1·53 and 1·52 volts respectively. It can be shown that the upper Σ state arises out of the $(4s\,5s)\,{}^3S$ term of the Ca atom and the lower from $(4s\,4p)\,{}^3P^\circ$ term of the Ca atom. This latter level should apparently be identical with the $^2\Sigma$ state of the red system. However, the discrepancy not only in the vibrational constants but also in the heats of dissociation points to a different Σ level for the final state of the orange system. The ultraviolet system has not been dealt with.

Details will be published elsewhere.

R. K. ASUNDI.
Physics Research Laboratories,
Muslim University,
Aligarh,
September 27, 1934.

Additional Bands in the Band System of Sulphur.

ON measuring my plates of the emission bands of sulphur produced in a discharge tube containing sulphur vapour in the presence of Argon, a few bands not previously recorded, have been observed. No bands could be traced to wave-lengths higher than 6612·3 Å. All bands from this wave length down till 4136 Å possess in the main, three heads, the strongest of them agreeing in wave-lengths with those of such of the bands as are also recorded by Fowler and Vaidya.* The following newly recorded bands fit in the scheme of vibrational analysis given by these authors and thus form part of the already known system of the S_2 molecule:

(v'v'')	λ_{air} (int)	ν (vac)
9,32	6612·3 (8)	15119
8,31	6545·0 (7)	15275
7,30	6476·3 (5)	15437
9,31	6382·7 (10)	15663
8,30	6316·7 (9)	15827
7,29	6251·5 (8)	15993

R. K. ASUNDI.
Physics Research Laboratories,
Muslim University,
Aligarh,
September 27, 1934.

Influence of Dissolved Electrolytes on the Constitution of Water.

RAMAKRISHNA RAO[1] has recently suggested that the changes with temperature in the distribution of the intensity of the three components of the Raman band of water at 3610 cm.$^{-1}$, 3413 cm.$^{-1}$ and 3195 cm.$^{-1}$ may be explained on the hypothesis that water consists of three types of molecules represented by (H_2O), $(H_2O)_2$ and $(H_2O)_3$, to which are attributed the above three components, and the changes in the relative proportions of which bring about the above intensity changes. He also suggested that the effect of dissolved electrolytes on water may also result in the formation of hydrates by the association of the molecules of water with the ions of the solute.

The above hypothesis was put forward on the basis of work with only a few electrolytes at a few concentrations. With a view to investigate how far this is applicable in general to all electrolytes at a large number

* *Proc. Roy. Soc.*, 1931, **132A**, 310.

[1] *Proc. Roy. Soc.*, 1931, **130A**, 489.

of concentrations, the author has, by a study of the changes in the structure of the Raman band of water, made a systematic investigation of the behaviour and constitution of water under the influence of several typical electrolytes dissolved in it. The results, which appear to confirm the above hypothesis, are given below.

The Raman band for water in solutions of electrolytes is invariably sharper than for pure water, the maximum of the band being nearly in the same position as that attributed to the $(H_2O)_2$ molecules.

With aqueous solutions of the few electrolytes that dissolve up to 8N and above (nitric acid, sulphuric acid, sodium nitrate, lithium nitrate and chloride have been thus far studied), the band gets sharper with increasing concentration of the electrolyte and shifts as a whole towards greater frequency. Also the portion of the intensity curve for the water band on the smaller frequency side, attributed to the $(H_2O)_3$ molecules, becomes less convex with increasing proportion of the electrolyte.

With hydrochloric acid, however, an anomalous result was observed, the band being sharper at the lower concentration, 8N, than at 11·7N, the shift of the maximum of the band also being in the opposite sense to that observed in the other cases.

All these results go to indicate the extreme stability of the double molecules $(H_2O)_2$, and the comparative instability of the other two types, triple $(H_2O)_3$ and single (H_2O), in solutions of electrolytes.

Whereas there is a progressive shift towards larger frequency in the water band in solutions of electrolytes at the same concentration, as we pass from lithium chloride to sodium nitrate and from hydrochloric acid to sulphuric and nitric acids, these differences tend to vanish when the water content in them, and not the amount of the electrolyte, is equalised. This observation goes to indicate that the change in water equilibrium between mono-, di- and trihydrol is the more probable cause of the effects observed, and the differences, though minor, that still persist at the same water content in the electrolytes studied may be either due to a change in the water equilibrium to different extents in the different cases, or to a difference of hydration in the several cases, or, what is more probable, to the simultaneous existence of both.

The cation appears to exert little influence on the behaviour of the solvent, as can be inferred from the similarity of results obtained with acids and salts.

The intensity curves of the water band in solutions of sodium nitrate are in general sharper than those for nitric acid, even when the latter is taken at a much higher concentration. This result may be partly due to the formation of more complex hydrates and partly due to the superposition of the NO_2OH band at 3420 cm.$^{-1}$ on the band due to water in solutions of nitric acid.

The results obtained by the author, therefore, go to show that the effect of dissolved electrolytes on the constitution of water may be partly to change the water equilibrium between mono- di-, and trihydrol, and partly to cause an association of the water molecules with the ions of the solute resulting in the formation of hydrates, the extent and complexity of which seems to be different for different substances. With the work so far done it is difficult to say more exactly how far each of these effects contributes to the results observed. A detailed report of these investigations has been communicated to the *Indian Journal of Physics*.

C. SAMBASIVA RAO.

Andhra University,
Waltair,
September, 1934.

Change of Resistance of Cobalt in Longitudinal Magnetic Fields.

DUE to the difficulty of obtaining the metal in suitable forms, a complete study of the change of resistance of cobalt in longitudinal magnetic fields had not been made so far. The transverse effect alone had been studied by earlier workers,[1] the metal being used in the form of thin films deposited on glass or some other surface. The only earlier worker who observed the longitudinal effect in cobalt was Paul McCorkle.[2] His curve for cobalt goes on increasing continuously and does not show any tendency to saturate even up to a field of about 1200 gauss. The resistance of nickel or iron increases in longitudinal magnetic fields, ultimately reaching a saturation value. This is a well-known fact verified by a host of observers, including McCorkle himself. His

[1] J. C. Beattie. *Phil. Mag.*, 1898, **45**, 243.
L. Grunmach, *Ann. der Phys.*, 1907, **22**, 141.

[2] P. McCorkle, *Phys. Rev.*, 1923, **22**, 271.

result for cobalt therefore is surprising and needs confirmation.

The writer has made a thorough study of the longitudinal effect in cobalt, using thin strips of the metal cut from a plate, certified by the makers to be of 95 per cent. purity. It has been found that the resistance does saturate, and also shows hysteresis. In the following table are given the values of the percentage change of resistance of cobalt in longitudinal magnetic fields. The magnetic field is increased gradually, and when there is no further change of resistance, the field is gradually decreased and brought back to zero. It is found that the resistance of the metal is now greater than the original resistance.

TABLE I.

Increasing fields	Percentage change of resistance	Decreasing fields	Percentage change of resistance
0·0 gauss	0·0	0·0 gauss	0·08
20 ,,	0·07	20 ,,	0·15
500 ,,	0·36	75 ,,	0·19
700 ,,	0·43	440 ,,	0·41
1020 ,,	0·55	890 ,,	0·54
1250 ,,	0·58	1300 ,,	0·58
1500 ,,	0·58	1500 ,,	0·58

The intensity of magnetisation in the specimens of cobalt was also measured and it was found that the maximum intensity was attained between 1200 and 1300 gauss. Thus it appears that the change of resistance saturates at the same time as the magnetisation. The change is always found to be an increase, as is evident from the above table. The writer has also been able to obtain the complete resistance-hysteresis cycle of cobalt in longitudinal magnetic fields. Full details will be published elsewhere.

This is for the first time that resistance-hysteresis has been observed in the case of cobalt. The fact that the increase of the resistance of cobalt saturates at the same time as the intensity of magnetisation, has also been observed for the first time.

The writer is indebted to the authorities of the Patna Science College for permission to carry on the investigation in the Physics Laboratory of the college, and the facilities afforded.

MD. SHARF ALAM.

Physics Laboratory,
Science College,
Patna,
October 3, 1934.

Smoke Pollution in Bombay.

THIS investigation of smoke pollution was undertaken on behalf of the Smoke Nuisances Commission, Bombay.

The following brief report (a fuller account with a new method of estimating the number of smoke particles will appear elsewhere) indicates the nature of variation in the number of smoke particles at various mill localities in Bombay.

Some observations were taken in dry weather in April while a few were made in monsoon in July on suitable rainy days. The results at each centre were taken both in the morning and in the evening.

April Results.

	Fergusson Road	Byculla Bridge	Lalbaugh	Sewri
Morning	2830	1930	2060	2940
Evening	3950	2990	3570	2780

July Results.

	Fergusson Road	Byculla Bridge	Lalbaugh	Sewri
Morning	2260	2380	2210	1260
Evening	3025	3050*	2215	1740

*The number in each column represents the average number of smoke particles per c.c.

It is seen that on the whole the evening number of smoke particles is higher than the corresponding value in the morning.

There is a difference between the evening results of April and July, and excepting the result marked (*), it is clear that the average number reduces by about 1000 to 1200 per c.c. in monsoon. This number may be attributed to smoke other than that of mills. There is no uniform variation in the morning results of the two months indicating that in the morning there may not be smoke other than that of mills.

The results indicate that the number of smoke particles per c.c. varies between 1200 to 4000 per c.c.

I thank the Commission for the permission to publish these results.

Y. G. NAIK.

Physics Department,
Royal Institute of Science,
Bombay.

September 1934.

Dry Ether as Solvent for Anhydrous Aluminium Chloride in Organic Synthesis.

THE author has made the interesting observation that dry ether which has the remarkable property of readily dissolving anhydrous aluminium chloride can be advantageously used for some reactions of the Friedal-Crafts' type which take place under mild conditions, *i.e.*, at or below the boiling point of ether.

Anhydrous aluminium chloride when added to dry ether quickly dissolves with evolution of heat and a clear colourless solution results in which the aluminium chloride is present in the form of a double compound with ether, $AlCl_3$, $C_4H_{10}O$.[1] This solution can directly be used for synthesis.

The author observed that the condensation of benzanilide-imido-chloride with polyhydric phenols in the presence of aluminium chloride to give anils of polyhydroxybenzophenones, proceeds best with dry ether as solvent. Ichaporia, working in this laboratory, has also found the use of dry ether as solvent advantageous for Shah and Chaubal's synthesis of dialkylaminobenzophenones[2] in which a benzanilide-imido-chloride is condensed with an aromatic tertiary amine with aluminium chloride as condensing agent. It is also found that a solution of aluminium chloride in ether can be used in place of a suspension of zinc chloride in ether for the Hoesch synthesis, *e.g.*, for the preparation of 2: 4–dihydroxybenzophenone from benzonitrile and resorcinol. All of these reactions are carried out in cold ethereal solution.

Ether would appear to offer an obvious advantage over some of the usual diluents like carbon disulphide, benzene, petroleum ether, in which aluminium chloride is insoluble. With ether as solvent, the reaction can be carried out in homogeneous solution.

The principal drawback to the general use of ether for this purpose is its tendency to react in some cases in the presence of aluminium chloride, the carbon-oxygen bond in ether being broken. The mixture of benzoyl chloride and aluminium chloride reacts with ether to give ethyl benzoate[3]. Triphenyl chloromethane in the presence of aluminium chloride and ether gives triphenyl methyl ethyl ether, which further gives by decomposition triphenylmethane and acetaldehyde.[4] The action of ether and aluminium chloride on diphenyl-dichloromethane is stated by the same author[5] to give benzophenone. It may be pointed out, however, that it seems more likely that no reaction takes place in the last case, and that the formation of benzophenone might be due to simple hydrolysis of the easily hydrolysable diphenyldichloromethane on subsequent treatment with water. Ether has also been known to act as an ethylating agent in the presence of aluminium chloride, but this requires high temperatures. Thus Jannasch and Rathjen[6] obtained diethyl phenol by heating phenol, ethyl ether and aluminium chloride at 145°. They similarly prepared hexaethyl benzene from benzene, ethyl ether and aluminium chloride.[7]

A detailed account of the experiments above referred to will be published elsewhere.

Attention is directed to the author's observation in as much as it may find application in some of the numerous organic reactions requiring the use of aluminium chloride as a condensing agent, which take place at relatively low temperatures.

R. C. SHAH.

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Bombay,

September, 1934.

The Biological Oxidation of Inositol.

INVESTIGATIONS have been carried out on the oxidation of inositol *in vitro* by animal tissues. The wide occurrence of inositol in plant and animal tissues would suggest

[1] *Cf.* Walker and Spencer, *J.C.S.*, 1904, **85**, 1106; Frankforter and Daniels, *J. Am. Chem. Soc.*, 1915, **37**, 2560.

[2] *J.*, 1932, 650.

[3] Norris, *J. Am. Chem. Soc.*, 1924, **46**, 2580.

[4] Norris, *loc. cit.*

[5] Norris, *loc. cit.*

[6] *Ber.*, 1899, **32**, 2391.

[7] *Ber.*, 1898, **31**, 1710.

that it has some important function which is not yet understood. We have carried out some experiments with the brain, heart, kidney and liver tissues of normal adult albino rats which have been fed on our standard mixed diet.

In the case of minced brain tissues, both washed and unwashed, inositol is oxidised. Minced heart muscle, also both washed and unwashed, gives an additional oxygen uptake with inositol. Kidney tissues have been studied, sliced as well as washed after mincing, and have been found to oxidise inositol. Liver tissues also appear to oxidise inositol though at a low rate.

The experiments were carried out with the Barcroft-Warburg apparatus in the usual way. The temperature of the thermostat was maintained at $37°\cdot3 \pm 0\cdot1$. The medium in which the tissues were suspended consisted of phosphate buffer at pH 7.4 and Ringer-Locke solution.

B. C. GUHA.
N. DAS.

Biochemical Laboratory,
Bengal Chemical and Pharmaceutical Works, Ltd.,
Calcutta,
September 10, 1934.

A Preliminary Note on the Morphology of the Aerial and Underground Flowers of *Commelina benghalensis*, Linn.

ALTHOUGH a very common weed, *Commelina benghalensis* is of great interest because of the presence of underground flowers in addition to the normal aerial ones. In the Indo-Gangetic Plains, this plant usually makes its appearance in the month of July and dies down towards the close of October. An examination of the spathes reveals the fact that each has usually three flowers enclosed within it. One of these and the first to develop has a longer pedicel than the other two, and is purely male (Fig. 1). Of the other two, which are hermaphrodite, one opens in the usual way and is chasmogamous (Fig. 2 B), while the other remains closed and is therefore cleistogamous (Fig. 2 C). The first flower naturally sets no seed and soon withers and drops off (Fig. 2 A). Of the other two, the chasmogamous produces seeds first and the cleistogamous a little afterward. Only the former comes out of the spathe; the latter remains bathed in the slimy fluid secreted within the spathe.

Each flower has 3 perfect stamens of which one is yellow and is larger than the two laterals which have a sky-blue colour. In addition to these there are 2 or 3 staminodes which are sterile. In some cases a very few pollen grains have been seen in the anthers of the staminodes also, but it is not likely that they are of any use in fertilisation.

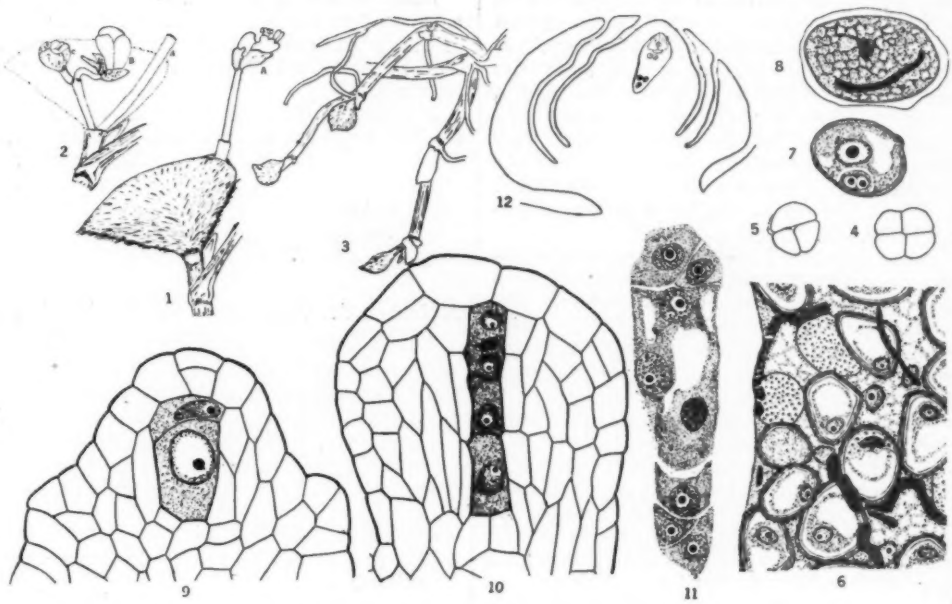
In addition to the blue aerial flowers mentioned above, every plant produces a large number of cleistogamous flowers borne on branches produced from the lower part of the stem (Fig. 3), which penetrate into the ground. While the aerial flowers occasionally fail to ripen, the underground ones are very fertile and the seeds are self-sown in the soil. A very similar condition has been reported by Hagerup[1] in *Commelina forskalei*.

The following account of the development of the gametophytes applies to both kinds of flowers, unless it is specially mentioned otherwise.

Microsporogenesis.—The early development of the anther presents no unusual features. The primary parietal layer divides periclinally to give rise to the endothesium, one middle layer and tapetum. The nuclear divisions in the latter are mitotic and the cells become binucleate at or even before the time of synizesis in the microspore mother cells. By the time the reduction divisions are over, the walls of the tapetal cells disorganise and the contents give rise to a true periplasmodium. It is noteworthy to record the presence of crystals of Calcium oxalate in the periplasmodium as also seen by Mascre[2] (1925) in *Tradescantia virginica* L. While they are not distinguishable in sections prepared according to the usual methods, they can be readily seen by crushing a fresh anther on a slide and examining it without any treatment whatever. At the microspore stage some rod-like bodies are also conspicuous in the periplasmodium (Fig. 6), but we have not been able to determine their exact nature so far. During the maturation of the male gametophyte, the nuclei of the tapetum begin to degenerate and finally the

[1] Hagerup, O., "On pollination in the extremely hot air at Timbucto," *Dansk. Bot. Arkiv.*, 1932, **8**, 1-20.

[2] Mascre, M., "Sur l'evolution de l'etamine des Commelinacees," *Bull. Soc. Bot., France*, 1925, **72**, 1060-1066.



1. Spathe enclosing 2 bisexual flowers and one staminate flower protruding out.

2. Same with spathe opened. The staminate flower at (A) has dropped off; of the two others, "B" is chasmogamous and "C" is cleistogamous.

3. Stalks bearing underground flowers and the fruits formed from them.

4, 5. Tetrads of microspores. × 310.

6. Part of a section of an anther showing the tapetal plasmodium and microspores. × 390.

7. Pollen grain with tube and generative cells. × 390.

8. Pollen grain with sickle-shaped generative nucleus and tube nucleus disorganised. × 390.

9. Nucellus with megaspore mother cell and primary wall cell. One of the epidermal cells has also divided periclinally. × 390.

10. Nucellus with tetrad of megaspores. × 390.

11. Eight-nucleate embryo sac. × 390.

12. Ovule with eight-nucleate embryo sac. × 86·5.

whole periplasmodium is used up by the time the pollen grains are ripe.

Male Gametophyte.—The divisions in the microspore mother cells are successive and the tetrads are isobilateral (Fig. 4), although occasionally they have the shape shown in Fig. 5. The microspore nucleus divides to form the tube and generative nuclei which are separated by a delicate plasma membrane (Fig. 7). The generative cell soon begins to take a deeper stain and often shows a sickle-shaped appearance in later stages. A feature of some interest is that in some pollen grains, the tube nucleus increases in size, its reticulum spreads, and finally breaks up to form small specks scattered in the pollen grain (Fig. 8).

When the anther is mature, the epidermis and the middle layer are practically disorganised and only the endothecium remains. Several attempts were made to find if the pollen grains germinated in the anther, but only a few such cases were seen and surprisingly enough the germination started not in the underground flowers but in the aerial ones. The pollen tubes were, however, very short and never reached even so far as the wall of the anther. Even if they could develop further, it is very doubtful if they could succeed in penetrating the endothecium which has the usual fibrous thickenings in all cases.

The Ovule.—The ovary is trilocular and contains 4 or 5 ovules, although sometimes

only 3 are present due to an early abortion of the others. Each ovule is campylotropous and has 2 integuments which are free from each other and also free from the nucellus throughout their entire length, a feature recalling the situation seen in Gymnosperms. In the older ovules they have a peculiar folded appearance and the nucellus forms a short beak-like outgrowth which comes up to the level of the micropyle (Fig. 12).

Megasporogenesis.—There is a single hypodermal archesporial cell, though occasionally two are present in some nucelli. The cells adjacent to the archesporial cells, however, often show similar staining reactions and simulate the sporogenous tissue in appearance.

Guignard (quoted in Schnarf[3]) mentioned that in *C. stricta* no wall cell is cut off. We have found several clear instances of the presence of a wall cell in *C. benghalensis*, but it is quite true that frequently the archesporial cell functions directly as the megaspore mother cell without cutting off any wall cell. A similar condition has been noted by Maheshwari[4] in *Ophiopogon wallichianus*, a member of the family Liliaceæ.

Another important point is the presence of a normal tetrad of megaspores (Fig 10). Guignard wrote that in *C. stricta* the development is of the Scilla-type, but this appears to be incorrect, for it is unlikely that the two species should differ so widely with regard to such an important point as this.

Female Gametophyte.—The chalazal megaspore functions and the further development of the gametophyte is of the conventional type found in angiosperms (Figs. 11, 12). The synergids have well-defined hooks and the antipodal cells are rather ephemeral. The two polar nuclei meet somewhere in the middle of the embryo sac or towards one side.

Fertilisation.—Numerous pollen grains were seen germinating on the stigma in both chasmogamous and cleistogamous flowers. Although we have seen but one case of actual fertilisation, the presence of pollen tubes in the older ovules seems to indicate that the process goes on in the normal way.

Endosperm and Embryo.—The endosperm is of the free nuclear type met with in other members of the family that have been investigated. The embryo is very slow in its growth.

A complete bibliography will be given in the full paper which will appear elsewhere.

P. MAHESHWARI.
BAHADUR SINGH.

Agra College,
Agra.
September 1934.

[3] Schnarf, K., *Vergleichende Embryologie der Angiospermen*, Berlin, 1931.

[4] Maheshwari, P., *Contributions to the Morphology of some Indian Liliaceae.* I. The gametophytes of *Ophiopogon wallichianus* (in the press).

A Note on the Presence of Parietal Cells in the Nucellus of *Convolvulus arvensis* L.

DAHLGREN[1] (1927) says that parietal cells in the *Sympetalæ* have been proved with certainty only in the *Plumbaginaceæ* and *Cucurbitaceæ*. In the *Convolvulaceæ* the absence of parietal cells has been reported in *Cuscuta lupuliformis* and *Cuscuta epithymum* by Dahlgren (1927) and in *Cuscuta reflexa* by Johri[2] whose paper is to be shortly published.

The presence of parietal cells in the *Convolvulaceæ* was first reported by Peters (1908)

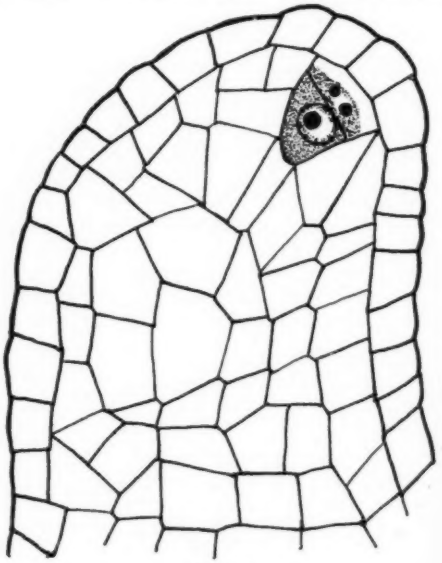


Fig. 1.

[1] Dahlgren, K. V. O., "Die Morphologie des Nucellus mit besonderer Beruck-sichtigung der deckzellosen Typen," *Jahrb. Wiss. Bot.*, 1927, **67**, 347.

[2] Johri, B. M., "The development of the male and female gametophytes in *Cuscuta reflexa*" (in the press).

both in *Convolvulus* and *Cuscuta*. This was regarded as doubtful by Dahlgren (1927) who

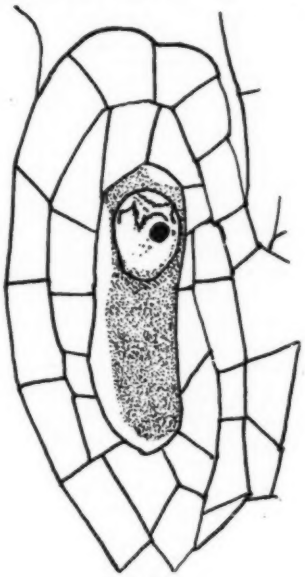


Fig. 2.

explains such appearances as being due to the sections not being cut parallel with the long axis of the nucellus.

During my work on *Convolvulus arvensis* I saw several median sections of the nucellus and from an examination of these I can state definitely that the primary archesporial cell cuts off a primary parietal cell (Fig. 1) which soon divides anticlinally with the result that the megaspore mother cell is separated from the epidermis by one layer of cells (Fig. 2).

I am greatly indebted to Dr. P. Maheshwari for kindly suggesting me this work.

KANHAIYA LAL MATHUR.
Government College,
Ajmer,
September 1934.

The Female Pre-pupa* of *Aptinothrips rufus*.

The description of some of the young stages of *Aptinothrips rufus* has been wanting. Priesner[1] has described the larval and pupal stages of the female. The pre-pupa markedly differs from the pupa in the position of the antennæ which are extended forward (Fig. 1) and from the larva in good many characters.

Total length 1·1 mm.

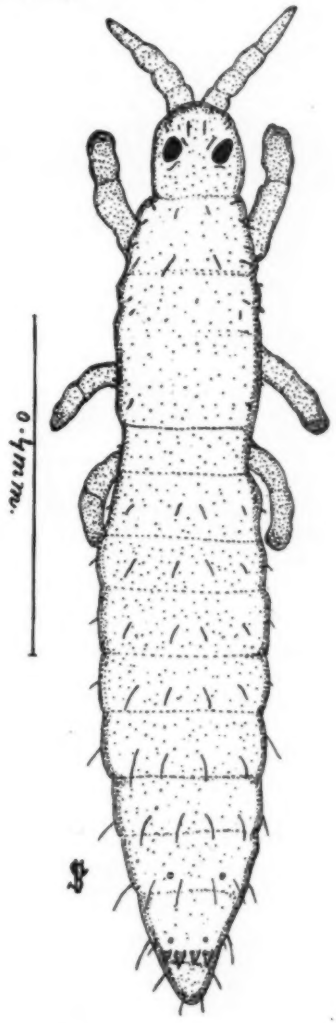


Fig. 1. The Female Pre-pupa of *Aptinothrips rufus* (Dorsal view).

General body colour—pale yellow; antennæ legs and abdominal tip—light and whitish. eyes reddish black.

Antennæ—smooth with bases near, lying straight in front of the head, about one and

* The specimens were collected in King's Park, Edinburgh, in 1931-32 and were identified with the collection of Dr. C. B. Williams, Chief Entomologist, Rothamsted.

[1] Priesner, H., *Die Thysanopteren Europas*, Wien, 1928, pp. 160-161.

one-fifth times as long as the head, clothed in a thin membrane. Various segments not clearly distinguishable, a few faint constrictions dividing it into four obvious joints; first, bowl shaped, wider than long; second, third and fourth longer than the first; the last segment about 3 times as long as the first.

Head—light yellow, rounded above eyes, almost as long as broad; cheeks parallel, eyes short. Hairs on the head very minute, one hair on each side below the lateral profile of the eyes. Mouth-cone not visible. Length 120 μ; width 126 μ; width across eyes 113 μ.

Prothorax—longer and wider than the head but wider than long. Sides subparallel with anterior and posterior angles rounded. Length 130 μ; width 160 μ; one very small hair each side behind the coxæ and two short hairs 23 μ situated at the posterior corners.

Pterothorax—longer than the head or prothorax, almost as long as the breadth of prothorax, wider than long. Length 166 μ; width 186 μ; Hairs very minute are situated on the sides.

Legs—not well differentiated into different parts. Length of fore, mid and hind legs almost equal.

Abdomen—pale yellow, fusiform, wider anteriorly and gradually tapering posteriorly ending in a blunt point. Segments not so clearly differentiated as in the larvæ. Length and (Breadth) of 1–7 segments are 40 (176) μ; 66 (186) μ; 73 (210) μ; 73 (220) μ; 76 (220) μ; 83 (210) μ; 70 (196) μ. Hairs on the abdominal segments are very minute. Each segment has a short lateral hair, the length of these from 1–5th segments being 23 μ; on the sixth and the succeeding segments the hairs are longer, about 43 μ. Some minute hairs are also situated on the dorsum. On the ninth segment at the posterior part, a short distance from the tip, are visible four short, strong thorn-like yellowish spines (25 μ long $\times$ 8 μ wide at the base). The thorn-like spines at the posterior part of ninth segment with undifferentiated antennæ lying in front of the head differentiates it from the larval and pupal stages.

U. S. SHARGA.

Govt. Agricultural College,
Cawnpore,
October 5, 1934.

The Multiplication of Scientific Societies.

THE well-meaning letter of Dr. Gilbert J. Fowler under the above heading, appearing in the September number of *Current Science*, does not appear to take sufficient account of the geographical difficulties in India, to which he incidentally refers. The need for the multiplication of local societies in this country like the Biochemical Society, Calcutta, is both great and urgent.

The formation of such regional bodies does not mean that opinion is against the existence of a central body, which, in fact, is necessary for co-ordinating research, preventing isolation as well as overlapping, issuing publications, etc. How exactly this co-ordination can be effected is a matter of detail.

As regards Biochemistry, I think, it should develop as a full-fledged independent science in this country as elsewhere, through its own organisations. There is unfortunately still a tendency in India to make it subordinate to Chemistry, Biology or Medicine. This does not appear to be in the interest of the science, although Biochemistry must necessarily be intimately connected with chemistry and the biological sciences.

B. C. GUHA.

P. 109, Lake Road,
Calcutta,
October 3, 1934.

I REGRET that Dr. Guha's letter seems to ignore the essential point that I strove to make in my letter in your September issue under the above heading. I wished to stress the importance above all things of a unity of interest in science to which geographical difficulties *should* be incidental.

In the case of Biochemistry the Society of Biological Chemists, India, having its headquarters in Bangalore where Biochemistry was first systematically taught in this country, has not sought in any way to work independently of existing organisations. Nevertheless, it has held valuable meetings, has published some useful monographs and Annual Reports and has a flourishing Branch centre in Bombay. It holds its Annual Meeting on the occasion of the Science Congress and has in fact so far represented the interests of biochemical workers throughout India. Its President is a distinguished Calcutta scientist and the

Executive Committee contains representatives from seven centres in addition to Bangalore. The contributors to the annual summary of Biochemical and Allied Research in India are equally representative.

The necessity, therefore, for a new Society is difficult to understand.

GILBERT J. FOWLER.

Bangalore,
October 8, 1934.

Research Notes.

On the Class-number of the Imaginary Quadratic Field.

RECENTLY Heilbronn (*Quarterly Journal of Mathematics*, **5**, 150) has proved an old conjecture of Gauss which remained unproved for more than a century. The knowledge about the class-number and the structure of the class-group of an algebraic field are of great importance in the theory of algebraic numbers. They certainly increase our knowledge of higher arithmetic. Unfortunately we know very little about them. Even in the case of the simplest fields such as the quadratic and cyclotomic fields very little is known. The latter field is important in connection with the great theorem of Fermat. The case of the imaginary quadratic field is very interesting as it is connected with many other branches of mathematical analysis. For instance, the equation of the singular moduli of elliptic functions is of degree equal to the class-number $h(-d)$ of the field $K(-\sqrt{d})$ where the ratio of the periods of the elliptic function belongs to $K(\sqrt{-d})$. The Galois group of the equation is isomorphic with that of the corresponding class-group. Gauss conjectured that $h(-d) \to \infty$ as $d \to \infty$. He also proved that the highest power of 2 contained in $h(-d)$ is 2^{t-1} where t is the number of odd prime factors of d. Dirichlet gave a finite expression for the class-number in terms of quadratic residues which he proved by transcendental methods. This is considered by most mathematicians as one of the most beautiful results in mathematics. That was the first time when transcendental methods were employed in the theory of numbers and this has grown to be a separate branch of mathematics since thirty years. There was great development in this branch especially during the past twenty-five years. After fruitless attempts by many scholars, Heilbronn has proved the first conjecture of Gauss by transcendental methods. Now Chowla (*Proc. Indian Acad. Sci.*, 1934, 1) by sharpening his methods slightly, proved that $\frac{h(-d)}{2^{t-1}}$ also tends to ∞ with d which includes another hypothesis of Gauss and Euler. This means that the degree of the equation of singular moduli tends to ∞ with d. Incidentally this also shows those values of d for which the equation is solvable by means of quadratic radicals only are finite in number. It is interesting to find out whether there are only 65 of them as was conjectured by Gauss and Euler. It appears that the upper bound of d obtained by these methods will be far greater than 1848 the highest number that Gauss has given.

K.V.I.

Zur Auflösbarkeit der Gleichung $x^2 - Dy^2 = -1$.

IT is known that the diophantine equation $x^2 - Dy^2 = 1$ has an infinite number of solutions for every value of D, but the equation $x^2 - Dy^2 = -1$ does not always possess a solution. A necessary condition for this is that it should be expressible as the sum of two squares but this is by no means sufficient. We have of course the continued fraction condition but this is neither a satisfactory one nor is it simple. The question of its solvability is important in connection with the class number and class field of $K(\sqrt{D})$. Epstein (*Jour. fur. Math.*, **4**, 171) treats this problem by very elementary methods and obtains the necessary and sufficient condition to be as follows. There should exist rational integers α, β, γ, δ, such that $D = \beta^2 + \gamma^2$, $K\beta - \gamma\delta 1 = 1$, and $\alpha^2 + \gamma^2$ is a square. Some other allied results are also given in the paper.

K.V.I.

Lineare Räume mit unendlich vielen Koordinaten und Ringe unendlicher Matrizen.

KOTHE and Toeplitz have contributed a very interesting and thoroughly developed paper (*Jour. fur. Math*, 1934, **4**, 171) on linear spaces with an infinite number of

coordinates and rings of infinite matrices in them giving a unified theory of maximal matrix rings in various spaces. The difficulties that arose in the solution of this problem have been conquered by introducing another related space, which is named the dual space and which is formed out of all points. $V = (u_1, u_2, \ldots, u_n, \ldots)$ for which $\Sigma u_n x_n$ converges for all points $X = (x_1, x_2, \ldots x_n, \ldots)$ of the original space. If the dual of the dual space is identical with the original, then the space is called perfect (Voll Kommen). With these definitions they proved the following theorem; *viz.*, "If the space is perfect then all its linear transformations form a maximal ring." The three spaces for which this theorem was known are easily shown to be perfect by the authors. We have here a separate proof which is very direct and simple.

Next they introduce the idea of convergence and strong convergence without the introduction of a metric as has been done by Hausdorff and Banach. This allows them to introduce homomorphy of two spaces and this has made it possible to consider the problem of obtaining all spaces homomorphic with a given perfect space. It is also shown how the problem of solving an infinite number of equations with an infinity of unknowns can be extended to spaces other than those for which the problem has been solved. The paper is complete in itself and is a very simple and elegant theory of linear transformations in generalised Hilbertian spaces.

K.V.I.

The Magnetic Moment of the Proton.

EVER since Estermann, Frisch and Stern (*Zs. f. Physik*, 1933, **85**, 4 and 17) found out that the magnetic moment of the proton was 2·5 nuclear magnetons instead of one nuclear magneton as was assumed before, the accurate determination of the magnetic moment of the proton has become a pressing problem which must be solved before any explanation of nuclear magnetic moments on a quantitative basis is attempted. Now I. I. Rabi, J. M. B. Kellogg and J. R. Zacharias (*Phys. Rev.*, 1934, **46**, 157) describe a new method developed by them for determining the protonic magnetic moment. Whereas Stern and his collaborators measured the protonic moment by a direct measurement of the force on a proton, a correction being made experimentally for the rotational magnetic moment of the molecule, the present authors have used a method involving the interaction between the proton and the valence electron. The experiment consists in deflecting a narrow beam of hydrogen atoms in the normal $^2S_{1/2}$ state by a weak magnetic field of sufficient inhomogeneity. Instead of assuming the two orientations $m_s = +\frac{1}{2}$ and $-\frac{1}{2}$, the atom takes up four positions corresponding to $(m_s, m_i) = (\frac{1}{2}, \frac{1}{2})$, $(\frac{1}{2}, -\frac{1}{2})$, $(-\frac{1}{2}, \frac{1}{2})$ and $(-\frac{1}{2}, -\frac{1}{2})$. The component of the magnetic moment of the atom in the direction of the field is respectively $f_1 = 1$, $f_2 = x/(1+x^2)^{\frac{1}{2}}$, $f_3 = -x/(1+x^2)^{\frac{1}{2}}$ and $f_4 = -1$. Here x is given by $x = 2\mu_0 \, H/hc\Delta\nu$ where H is the magnetic field, and $\Delta\nu$ is the hyperfine separation between the levels F=1 and F=0 in cm.$^{-1}$ Then $\Delta\nu = (32\pi/3hc)\,\mu_p\,\mu_0\psi^2(o)$ or putting in numerical values $\mu_p = \Delta\nu/0{\cdot}0169$. The deflection of a beam is given by

$$S_d = \frac{f_j \mu_0}{4kT} \times \frac{\delta H}{\delta y}(l_1^2 + 2l_1 l_2)$$

where f_j are the functions mentioned above, l_1 and l_2 are the distances the atom moves in the field and outside the field. The atoms are produced in a long Wood discharge tube. They pass through slits and traverse the inhomogeneous magnetic field due to two wires carrying a current and the deflected beam is detected by means of a plate covered with molybdenum oxide which turns blue where the atomic hydrogen falls on it. The value obtained for the protonic magnetic moment was $3{\cdot}25 \pm 10\%$ nuclear magnetons. The discrepancy between this and Stern's value $2{\cdot}5 \pm 10\%$ is rather large, but at present the substantial agreement of the two results is more important than their difference.

The Magnetic Moment of the Deuton.

THE magnetic moment of the deuton is a very important quantity since the deuton is the simplest composite nucleus and a study of its magnetic moment is necessary for an understanding of nuclear structure. Theoretical explanations of nuclear magnetic moments depend upon the assumed value of the magnetic moment of the neutron. There is a conflict of opinion regarding this quantity, Schüler and his collaborators considering it to be $-3{\cdot}5$ while Landé and Inglis, and Altschüler and Tamm hold it to be $-0{\cdot}6$. The

magnetic moment of the deuton must throw some light on that of the neutron since it consists of a neutron and a proton. I. I. Rabi, J. M. B. Kellogg and J. R. Zacharias (*Phys. Rev.*, 1934, **46**, 163) have determined the magnetic moment of the deuton by the method they have developed for the proton and described in a previous note in this journal. They obtain the value $0{\cdot}77 \pm 0{\cdot}2$. Since their experimental method does not determine the sign of the magnetic moment the value for the proton may be $\pm 3{\cdot}25$ ($\pm$ 10%) while that of the deuton is $\pm$ $0{\cdot}77$ ($\pm 0{\cdot}2$). If the magnetic moments of the proton and the neutron are supposed to add together into that of the deuton, the magnetic moment of the neutron must be about $\pm 2{\cdot}5$ or $\pm 4{\cdot}0$ according as the magnetic moments of the proton and neutron are directed opposite to each other or in the same sense.

A New Method for the Determination of Transport Numbers.

THE "Balanced boundary method" developed by Hartley and co-workers (*Trans. Faraday Soc.*, 1934, **30**, 648–662) provides a long-felt want in the moving boundary technique for the determination of transport numbers. Hitherto, one had but to resort to the less accurate Hittorf method for determining the mobilities of the more slowly moving ions. For, one is confronted with a great difficulty in finding a suitable "indicator ion" in such cases. This difficulty is eliminated in the present method by having the slow moving ion in the indicator position and determining its mobility by taking advantage of the Kohlrausch relation:

$$\frac{T_R}{C_R} = \frac{T_X{}^k}{C_X{}^k}$$

where T_R and $T_X{}^k$ are the transference numbers of the leading and the indicator ions at their respective concentrations C_R and $C_X{}^k$, the latter referring to the concentration of the indicator ion in the Kohlrausch solution (and not in the initial solution).

Conductimetric analysis *in situ* is shown to be inapplicable for determining the composition of the Kohlrausch solution, owing to the interference by the cyclic electrolysis taking place at the A.C. electrodes. An ingenious device has been adopted for displacing samples of Kohlrausch solution into an external conductivity cell, without the interruption of the direct current. A new method of getting at a sharp boundary has also been described.

The method has been tested by measurements with electrolytes whose transference numbers are known and is shown to be capable of a high degree of accuracy.

K.S.G.D.

The Significance of X-Bodies in Virus-Infected Plants.

THE occurrence of cell inclusions in plants caused by viruses or ultramicroscopic organisms, has been recorded in a comparatively few cases, chiefly the mosaics. Apart from their ætiological significance as the prime cause of disease, their utility for diagnostic purposes is quite limited to the few cases known so far. The simple question why these bodies are not to be traced in other cases of virus attacks, has been engaging the attention of several workers. It has been held in some quarters that these are mere artefacts probably brought about through abnormal metabolic products resulting from infection and reacting with the fixatives employed in the cytological technique. Since biochemical changes consequent on virus attack need not be the same in all species of plants examined, this reaction to coagulating agents, apparently identical in the few instances known, may be due to similar changes induced in the different host plants. Whether this is so or not, is a matter for biochemists to investigate. It will, however, readily be seen that these new aggregates or X-bodies result from virus infection and can by no means be construed as the cause of disease. The most recent contribution on this subject is due to Sheffield (*Ann. Appl. Biol.*, 1934, **21**, No. 3). Following his previous announcement on the action of molybdenum on cells, the author chooses two lines of investigation—the first on the action of coagulating agents on the cytoplasm and the formation of bodies in uninfected plants and the second on the possibility of inhibiting the formation of the same through chemicals in virus-infected plants. For want of adequate knowledge on this problem, the author has to adopt miss or hit methods, as the choice of chemicals lies within wide limits. Among those tried many are fixatives used in cytology. The reason for selecting nickel, molybdenum,

etc., are apparently due to the presence of these in such plants. One wonders if these are exclusively present in diseased cells alone. Moreover, the choice of tissues is indeed the prime factor in such studies and offers the greatest difficulty. In spite of this, the attempt made by the author is a valuable one, though cursory. The technique adopted is simple and neat. The intra-cellular changes have been followed closely. Practically everyone of the reagents employed, has been able to induce stimulation of the cytoplasmic stream similar to that which is observed as a result of virus infection. The author has detailed his observations on the action of ammonium molybdate and reproduced in a striking manner, the formation of bodies similar to those observed in aucuba mosaic. It has been argued by the author that this phenomenon is not due to a secondary effect, since analysis of treated plants showed an 'abundance' of molybdenum. It may, however, be suggested, that the application of such heavy chemicals might result in the non-availability of certain essential nutrients, particularly phosphorus in this case. This reaction to such treatments may be intense when the chemical is added to the soil. Several other coagulating reagents were tried and have responded quite similar to the above—thus lactic acid induces the formation of amoeboid bodies—resembling the X-bodies of tobacco mosaic.

The second technique of inhibiting the formation of such bodies in virus-diseased plants or of dispersing the same artificially after their formation, has not yielded any positive result. The subject is one of great interest and it is hoped ere long a further contribution on the same will be made available for the benefit of others engaged in the same field.

V. I.

Synthetic Resin Hyrax.

IN a recent note to the *American Mineralogist* (August 1934, **19**, No. 8) E. N. Cameron of New York University has discussed the utility of synthetic resin Hyrax as a mounting medium; and it comes as a welcome relief to many petrographers and mineralogists since the use of Hyrax as a medium for mounting minerals has got a decided advantage in certain cases over Canada Balsam. Since Hyrax has a high index of refraction it will be useful for (i) increasing the relief of minerals which have indices of refraction close to that of Balsam; (ii) decreasing the relief of minerals which have indices of refraction much above that of Balsam; (iii) facilitating the identification of certain minerals. Hence the use of Hyrax as a medium for permanent mounting of grains belonging to mineral assemblages in sedimentary petrography is obvious. The photomicrographs reproduced in the paper further show that intergrowth of minerals can be better studied when mounted in Hyrax.

Periodicity of Earthquakes.

CHARLES DAVISON, the noted seismologist, has contributed a very interesting paper on the diurnal periodicity of Earthquakes in the July-August number of the *Journal of Geology* (**42**, No. 5). By counting the number of Earthquakes occurring during each hour of the day from the recorded observations from Great Britain, Japan and Italy, he has shown by means of a curve that the maximum falls at midnight and at noon. Considering the causes of earthquakes, he has further suggested that if the earthquakes were mainly due to depression of the crust, the diurnal and annual seismic epochs would occur about midnight and midwinter. If the earthquakes were mainly due to elevation of the crust the epochs would occur about noon and midsummer. Further an important conclusion has been established that the midnight and the winter maxima prevail in regions where the earthquakes are of low intensity, and the noon and summer maxima in regions visited by much destructive shocks.

The Idiochromosomes of an Earwig *Labidura riparia*.

J. J. ASANA and SAJIRO MAKINO (*Jour. of Morph.*, 1934, **56**, No. 2, 361-370) describe the behaviour of the chromosomes in the Indian Earwig *Labidura riparia* with special reference to the idiochromosomes. The diploid number is 14—6 pairs of autosomes and XY in the male and 6 pairs of autosomes and XX in the female. The autosomal constitution of this species differs from that of the American forms described by Morgan; the latter has two chromosomes less than the former. The X and Y chromosomes have been traced to a single chromatin nucleolus derived from the nucleolus

of the last spermatogonial division. The chromatin nucleolus retains a clavate form through the early and late periods of growth and this form is retained till the metaphase of the first spermatocyte division is reached. It is suggested that the behaviour of the chromatin nucleolus of *Labidura riparia* resembles that of the chromatin nucleolus of Oecanthus described by Makino.

A Cytological Study on the Liver of the Rat with Special Reference to the Intracellular Blood Canaliculi, Inter- and Intra-cellular Bile Canaliculi, Mitochondria and Golgi Apparatus.

EDITH M. JAY (*Jour. of Morph.*, 1934, **56**, No. 2, 407-421) makes an interesting contribution to the cytology of the liver and interprets the so-called 'intracellular blood canaliculi' described by Schafer and his pupils as artefacts produced by the differences in the osmotic pressure and the mechanical pressure employed in administering the injection masses. She further demonstrates that a permanent system of intracellular bile canaliculi described by the earlier authors does not exist and that the short knob-like intracellular projections from the intercellular bile canaliculi possibly represent the passage of the secretion into the intracellular canaliculi. Though the presence of glycogen effectively hinders the processes of impregnation, her observations on the Golgi apparatus and mitochondria confirm those of Cramer, Ludford and others.

Irrigation Research in the Punjab.

THE investigations that are being carried out in the Punjab have as their objects the improvement of design of irrigation works, the reduction in the costs of maintenance of channels, the control of the rise in water-table and the prevention of soil deterioration under irrigation. In order to carry out these investigations the following Sections of the Research Institute have been established—Hydraulic Section, Physics Section, Chemical Section, Land Reclamation Section, the Statistical Section and Mathematical Section. A brief account of the work of each of these sections will indicate the lines of work that are being pursued.

1. HYDRAULIC SECTION.

The essential features of a canal headworks in the Punjab are a weir across the river to obtain command of the land and the head regulator of the canal. One or more bays of the weir are provided with under-sluices for purposes of regulation. The weir consists usually of an upstream apron, the crest, the down-stream glacis, and below this the block protection. If the weir fails, the whole of the irrigation in the canal system may fail. It is of the greatest importance, therefore, to design a weir so that it will stand up to the strains imposed upon it. Experience has shown that weirs may fail due to the floor not being heavy enough to withstand the unbalanced head. The pressure under the floor of the weir may be greater than the pressure on the floor. If this is the case and the floor is not strong enough, the floor may be lifted with disastrous consequences. The pressures under the floor as influenced by various forms of design have been studied and, as a complement to this, methods for controlling the flow on the floor have been investigated.

The methods for investigating the flow under a work have already been described.[1] The tanks used in these experiments have been adapted to study the pressures and it is now possible to place a model of a work in the tank and determine accurately the pressure that will be experienced on any portion of the floor. Fig. 1 is an illustration of a model of Khanki Weir, Bay 4.

In order to examine the condition of flow over the weir a scale model of a section of the weir was constructed in the flume and the effects of the different conditions of flow actually experienced on the work were examined. In order to render a work safe, it is essential that the velocity of flow in contact with the floor should be as low as possible. The methods that have usually been adopted to secure this have had as their basis the destruction of energy. The subject was examined from an entirely new point of view in the Punjab Laboratory. If the high velocity water could be thrown to the surface and a low velocity water be made to travel along the floor, the problem would be solved since a high velocity water at the surface could do no damage. It has been found that by placing arrows a short distance below the crest of the weir and raised control blocks at the end of the floor, the flow along the floor is extremely slow. Determinations of the velocity of flow show that the arrows throw the high velocity water to the surface and the raised blocks check the flow of the bottom water. Under these conditions no standing wave, as usually understood, is formed. Instead a wave which has only a forward motion is produced. In order to distinguish this wave from the standing wave it has been designated "forced jump". Fig. 2 shows the design adopted for the down-stream protection of Khanki Weir.

An examination has now been made of the prototype after the weir, according to the new design, has been in operation for one flood season. It has been found that the form of flow over the weir is identical with that predicted from the model experiments and that the greatest settlement of the loose blocks has been 0·5 foot, while the majority have not settled more than

[1] *Curr. Sci.*, 1934, **2**, 367-370.

0·2 foot. This will result in a large reduction in the cost of maintenance of the weir since large scour holes down-stream had to be filled annually with stone at considerable expense.

One further important result of these investigations is worth noting. Before these studies were made, it was impossible to obtain information upon which the designs of the floor could be based. Since it is now possible to determine the pressures under the floor and also the profile of the water surface on the floor, the unbalanced head can now be evaluated and the position that this will occupy on the floor can be stated. As a result the thickness of the floor can be calculated and the area requiring reinforcement can be determined. The design of Bay 8 of Khanki Weir which is to be reconstructed during the Cold Weather of 1934-35 has been based on these laboratory experiments. Further work on the same subject is in progress with the object of adapting arrows and raised control blocks to canal falls.

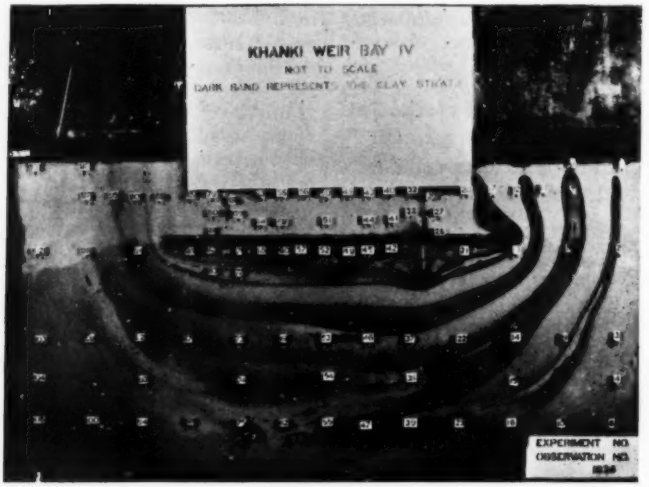


Fig. 1.

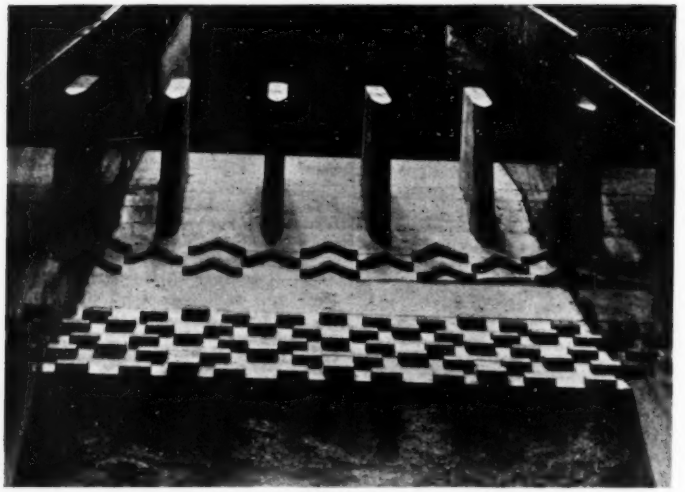


Fig. 2.

Another important investigation now in progress in the Hydraulic Section is the study of the silt in canals. The Physics Section has collaborated in this investigation by designing a Siltometer which can be used for deriving the distribution curve of the bed silt. If silt accumulates in the bed of a channel, the channel must become wider in order to carry the designed

supply. This widening of the channel entails a large expenditure to protect the banks. The object of the investigation is to study the relation of the silt type to the hydraulic data of the channel. Observation sites have been established on a number of channels and the hydraulic data that has been collected is being examined in conjunction with the characteristics of the bed silt at the site.

The silting of the Upper Bari Doab Canal has been thoroughly examined both at observational sites and on models. As a result a silt ejector has been designed and constructed for dealing with the silt. This ejector is now returning to the river about thirty per cent. of the silt entering the canal. Extensions of the ejector are to be made with the object of controlling the remainder of the silt. As a result of this silt control maintenance costs will be considerably reduced and the re-modelling of channels will become unnecessary.

2. Statistical Section.

The research work of the Statistical Section has been mainly concerned with the investigation of the factors responsible for the rise in water-table in irrigated areas in the Punjab.

The data for the work are the records of well levels, the rainfall, the canal discharges and the areas commanded. Fortunately the level of water in the wells has been recorded from a considerable time. The first area investigated was that commanded by the Upper Chenab Canal in which water-logging is a serious problem. It has been shown that the variation in the level of the water-table is directly related to the amount of the monsoon rainfall. Fig. 3 shows the relationship between the rise in water-table between June and October and the monsoon rainfall.

It has also been demonstrated that there is no significant relation between the amount of irrigation water that the land receives and the rise in water-table. From the data it has been shown that the greater the amount of irrigation water that the land receives the less is the rise in water-table between June and October. This is due to the fact that in years of low rainfall there is a keen demand for canal water, while in years of high rainfall the demand for water is relatively small. Since it has been shown that the monsoon rainfall is the factor determining the variation in the water-table, the foregoing result as regards irrigation is to be expected. Before the investigations of the causes of the rise in water-table had been carried out, canal closures were tried as an anti-water-logging measure. These have now been discontinued as they have been shown to be of little value and interfere with agricultural operations to a harmful extent.

Since the monsoon is a characteristic of the climate of the Punjab, objections to the above conclusions have been raised on the ground that water-logging was not a serious problem before the advent of the canals. The reason for the monsoon rainfall now causing water-logging is that the canals and distributaries frequently block the natural drainage lines and the land in these drainages is now cultivated thus preventing any run-off. Government has now accepted this view and has sanctioned a programme of drainage development over a period of five years. The importance of drainages as part of any scheme for irrigation development has now been recognised and attention will be paid to this in all future projects in the Punjab.

As a result of these investigations, the Statistical Section has been called upon to examine alterations in alignment of channels and in water supplies from the point of view of water-logging. In addition to this major problem, the results obtained from the silt observation sites and the pressure observation on models of works are dealt with.

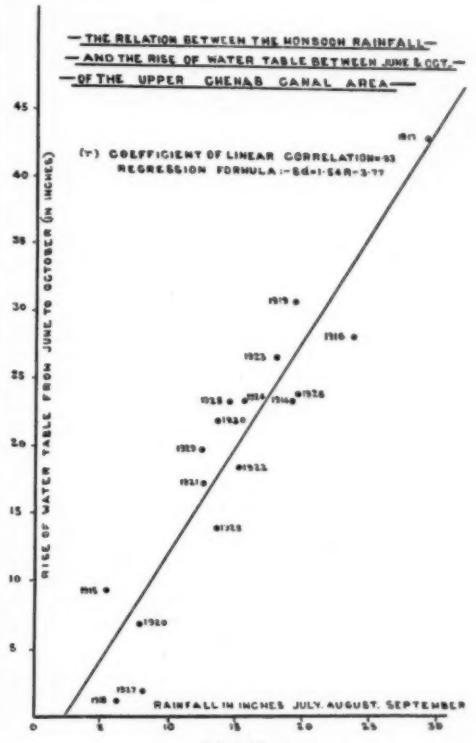


Fig. 3.

3. Chemical and Land Reclamation Sections.

The Irrigation Research Institute is unique in that it not only studies the design of works and the running of channels but also deals with the effect of the water on the land irrigated. One of the major irrigation problems in the Punjab is the deterioration of land under irrigation. As the Punjab is an agricultural province any deterioration in the soil must mean a reduction in revenue. Further, while there is sufficient water in the Punjab rivers for the present irrigation, it is doubtful whether it would be sufficient for land reclamation, a process that would have to be undertaken if land were allowed to deteriorate on a large scale. In the case of the Punjab, land deterioration may be defined as the replacement of the exchangeable calcium in the soil by sodium which results finally in the production of a soil in which alkalinity limits crop production. The soils of the Punjab plain are characterised

by an alkaline reaction and the presence of sodium salts in varying proportions. Under irrigation the tendency is for the salts present in the soil to circulate in the surface layers with the result that either the salt content or the alkalinity increases.

Extensive soil and crop surveys have been made recently and these have shown that when the pH value of the soil rises above 8·5, the crop yield tends to diminish and when the pH value rises above 9·0, rice is the only crop that can be grown successfully. When the pH value rises above 9·6 even rice cultivation is a complete failure. Large areas have already gone out of cultivation on account of the increase in the alkalinity and salt content of the soil. A much more subtle change is, however, also taking place in the irrigated areas. Since the soil usually contains small quantities of salts, base exchange reactions will take place. The rate at which these reactions take place will be slow and hence the deterioration may pass unnoticed until it has become acute. Recent work in the laboratory has been devoted to the study of these reactions. It is well known that calcium salts can react with a sodium clay to form a calcium clay. What does not appear to have been realised is that the presence of a calcium salt in the soil can *prevent* the reaction between a sodium salt and the clay. This discovery is of considerable importance as it at once points to the method for the prevention of land deterioration under irrigation. The periodical application of gypsum to the land under irrigation prevents the exchange reaction between the sodium salt and the soil and, hence, maintains the land in its original state of fertility. Since it has been shown that crop yields decline when the pH value of the land exceeds 8·5, gypsum should be periodically applied to land of this pH value to prevent further alkalinity being produced. As slow deterioration of this type may pass unnoticed it is essential to have periodical surveys of the irrigated areas so that the necessary steps can be taken to check soil deterioration before it becomes serious.

The quality of irrigation water is a subject closely allied to that of soil deterioration. Investigations carried out in the Research Institute have shown that in the case of the best Punjab soils, base exchange takes place between the clay and a sodium salt when the latter is present to the extent of 60 parts per 100,000. It has already been shown that the presence of calcium salts in the water can prevent this exchange reaction. The quality of irrigation water has to be considered, therefore, not only from the point of view of total salts but also from the standpoint of the ratio of calcium to sodium ions in solution. Standards based on this ratio are now being used for classifying Punjab waters. This investigation is of considerable importance in connection with the use of drainage waters for irrigation and also in connection with the proposed development of tube-well pumping in the Punjab. In the case of drainage waters, it frequently happens that the drains have no outfall and hence the water has to be pumped into canals and distributaries in order to dispose of it. It is essential to control the amount of water pumped from the drains if the mixed waters are not to be harmful.

A further important point in connection with the quality of irrigation water has recently been brought to light. The quality of the water is not only determined by the salts in solution, but also by the characteristics of the soil to be irrigated. It has been shown that the higher the pH value of the soil, the greater is the quantity of sodium ions in solution necessary to cause base exchange to take place. It follows from this that the higher the pH value of a soil to be irrigated, the higher can be the concentration of salts in solution without causing soil deterioration. A soil survey of the land to be irrigated is as essential as the examination of the water supply in deciding whether the water is fit for irrigation purposes in a particular area.

The complement to the laboratory investigations is the field work which is being carried out at the Chakanwali Research Farm. Rice is one of the few crops that can be grown on a soil with a high pH value. It is, therefore, the first crop to be taken during the reclamation of alkaline or salt land. It has been demonstrated, however, that rice plays a definite part in the reclamation process which consists essentially in removing the exchangeable sodium from the soil. Under the rice crop the carbon dioxide produced by the roots assists in the removal of the exchangeable sodium converting it finally into sodium bicarbonate which is removed in the drainage water. A considerable amount of information has now been acquired as to the types of Punjab soils that can be reclaimed and the types that cannot economically be brought under cultivation. The information gained has been of great value in connection with the soil surveys for project purposes. As the main factors limiting crop production on Punjab soils are alkalinity and salts a classification based on these factors has been reached which indicates their probable crop-producing power.

From the analytical results of the soil surveys, soil maps are prepared showing the soil classifications of the areas. For project purposes it is considered that if sixty per cent. of the land to be irrigated is not classified as directly culturable the project is unlikely to be financially successful.

4. Physical Section.

The Physical Section is a relatively recent addition to the Institute. The work of this section has been developed along two main lines: (*a*) the investigations of the characteristics of silt, and (*b*) the study of the seepage from canals.

The only satisfactory method of characterising a silt is by the distribution curve for particle size. The first work of the Physicist was to evolve a suitable instrument for determining the distribution curve. An ingenious Siltometer based on the principle of the optical lever was developed and is now adopted as the standard instrument in India for silt analysis. A series of observation sites on a number of canal systems were selected. The hydraulic data of the channels at these sites are taken daily and bed silt samples of the sites are also obtained. When a sufficient amount of data has accumulated it is hoped that it will be possible to determine a relation between the hydraulic data of the channel and some characteristic of the bed silt. At present from the form of the distribution curve it is possible to say whether the channel is silting or scouring, whether the channel has poor command, whether the channel has a stable bed or not and whether the channel

conditions are likely to improve or not. It is becoming more and more evident that one of the most reliable indications of the behaviour of a channel is the character of the silt as determined by the distribution curve.

Seepage losses from canals are important for a number of reasons. Any loss by seepage is water-wasted ; seepage may lead to water-logging in the neighbourhood of the canal and an allowance has to be made for seepage losses in determining the amount of water that must be supplied at the head of a channel to irrigate a given area. The study of seepage losses has been carried out both in the laboratory and in the field. The laboratory work has involved the study of the transmission coefficient of sands and soils. A relationship has been developed between the transmission coefficient and the distribution curve for particle size. It is now possible from the distribution curve to determine the probable transmission coefficient. The field-work has shown that soil type is the main controlling factor in seepage losses. The presence of salt in the soil does, however, increase considerably the seepage losses in soils that would be impermeable as determined by the distribution curve.

The Institute has also carried out investigations for Government Departments other than the Irrigation Branch. The investigation of soil temperatures in connection with the capacity of underground cables, the examination of the causes of failure of plantations, the investigation of methods of increasing the fodder supply in *barani* tracts, and the study of forest soils are instances of the work that has been carried out.

From this brief account of the research work now being done, it will be seen that attention is mainly devoted to problems of immediate practical importance. Work of a more fundamental nature is being undertaken in all sections, but until the investigations into problems of immediate practical value have been completed, this side of the Institute's activities must be curtailed.

The Art of Chromium-Plating.*

By K. B. Parekh.

THE last decade has seen an enormous development in chromium-plated finishes applied to a variety of domestic and industrial articles. The merits of chromium as compared with nickel or silver plating have been thoroughly established, and there are at present in Great Britain more than 600 plants in operation. Perhaps the most striking characteristic of an electro-deposit of chromium is its stainless brilliancy and the ease with which the surface of chromium-plated articles can be restored to their original lustre, merely by wiping with a damp cloth. In addition, its extreme hardness and resistance to tarnish furnishes a plating that amply justifies the popularity it enjoys for numerous purposes.

Although chromium-plating was known eighty years ago the perfection in the art reached to-day is of comparatively recent origin. This is due to special difficulties of a technical nature involved in the process of chromium-plating, which could be solved only after a prolonged and intensive study of the problem.

Bloom, Piersol and others have contributed much towards the solution of the problem. In the case of chromium against other metals, the plating range is very critical, hence, current density, temperature, concentration of the bath, etc., have to be carefully controlled. Other difficulties of a special nature are connected with (1) choice of suitable anodes, (2) poor throwing power and (3) evolution of gases and porosity of the deposit.

Instead of the simple form of soluble anodes employed for every other form of electro-plating, chromium-plating calls for insoluble compound anodes whose composition also influences the success of the operation. Most suited anodes are those of lead-antimony alloy (lead : antimony :: 94 : 6).

At any given temperature the character of the deposit and also the cathode efficiency vary with the current density. On irregularly shaped articles the current density is never uniform. Consequently, in plating such articles it is difficult to obtain a bright deposit over the entire surface. The coating on the recessed part may be very thin or entirely lacking. This poor throwing power, however, is a decided handicap and has taxed the patience of those engaged in commercial chromium-plating. This has been overcome in practice by more or less empirical methods. Best results have been obtained by expedients that make the cathode current density more uniform such as, by increasing the distance between anodes and cathodes, using concentric or auxiliary anodes, or attaching a wire to the cathode which acts as a "thief" and takes away the excess current from points nearer to the anode.

In the usual chromium-plating bath, a considerable amount of hydrogen and oxygen are evolved and these carry along with them chromic acid in the form of a fine spray. These sprays can perforate the nasal septum and cause sores on the hands and feet of the workman. The chromic acid spray can be minimised to a certain extent by covering the bath with a layer of kerosene or paraffin oil. But in commerical plating, the gases are removed by adequate ventilation. As the chromium deposit occludes a large amount of the hydrogen, the plating is frequently full of pores and cracks if suitable precautions are not taken. Very thin coatings contain round pores. As the thickness is increased the porosity decreases, reaches a minimum and then increases with the thickness till large cracks are formed either in parallel or at random. Under the usual conditions of deposition there is a minimum porosity when the chromium coating is about 0·00002 inch thick. Further, due to the extreme hardness of deposit it is impossible to buff or burnish the articles so as to obtain a better finish as is the

* Abstracted from a lecture delivered before South Indian Science Association on 24th September, 1934.

case with articles plated with other metals. It is essential that the articles be polished, burnished and finished to the highest order before plating, as the final lustre depends much on this preliminary operation. In the case of iron and steel preliminary plating with copper or nickel or both, is given before being chromed.

Among the several applications, the increasing use for domestic and other articles exposed to air, is well known. Its special use, for taking advantage of the wear-resisting properties, is found in the chromium-plating of fine measuring gauges and in the printing industry. The life of certain textile machinery and equipment has been surprisingly lengthened by this means particularly as regards copper printing rolls and Schreiner rolls.

Science Notes.

Inhibitive Power of Agar.—Dr. B. N. Desai and his collaborators of the Wilson College, Bombay, in a communication on this subject, write: "It has been shown (Desai and Naik, *J. Bombay University*, 1933, 2, Part 2, 90) that the power of gelatine to prevent precipitation (inhibitive power) depends upon its pH besides its concentration and that the inhibitive power is different with reference to different salts which are precipitated in the gel. Thus it has been found that the inhibitive power of gelatine is minimum for gelatine of pH 5·75 with reference to precipitation of Ag_2CrO_4, maximum for gelatine of pH 5·00 with reference to precipitation of PbI_2 and continuously decreases with a decrease of pH of gelatine with reference to precipitation of AgI. In another paper (Naik, Desai and Desai, *J. Ind. Chem. Soc.*, 1934, 11, 45) it has been pointed out that the term "Inhibition" should be used to indicate power to prevent precipitation generally whether it may be due to production of super-saturated solution or of colloidal solution or of particles in a very highly dispersed condition.

"We have been doing similar work with agar and the purpose of this note is to give a summary of the results obtained so far. The following cases of precipitation in agar have been studied: (1) PbI_2 from solutions of $Pb(NO_3)_2$ and KI, (2) $PbCrO_4$ from solutions of $Pb(NO_3)_2$ and K_2CrO_4, (3) AgI from solutions of $AgNO_3$ and KI, and (4) Ag_2CrO_4 from solutions of $AgNO_3$ and K_2CrO_4. pH of agar was determined colorimetrically and samples of different pH were prepared by adding suitable amounts of acetic acid and sodium acetate. The inhibitive power was found out by determining the amount of salt (PbI_2 or $PbCrO_4$ or AgI or Ag_2CrO_4) that can be kept in the mixture for one minute without producing any precipitate, the amount of agar and the total volume of the mixture being kept the same throughout. The pH range tried in these experiments is 2·40 to 9·02, the pH of original sample of agar being 5.94. It is observed that the inhibitive power of agar with reference to different salts varies with an increase of its pH in the following manner:—

(1) PbI_2—The inhibitive power increases upto pH 5·94, decreases thereafter upto pH 6·78 and again increases with an increase of pH.

(2) $PbCrO_4$—The inhibitive power is minimum for pH 5·94, being greater for higher or lower values of pH.

(3) AgI—The inhibitive power increases upto pH 5·94, decreases thereafter upto pH 7·00 and again increases with an increase of pH.

(4) Ag_2CrO_4—The inhibitive power is minimum for pH 7·00, being greater for higher or lower values of pH.

"It would appear that the iodides of both the metals behave in one fashion and the chromates in another fashion. The condition of these substances with special reference to the nature of their Liesegang rings in agar is being investigated. Details will be published elsewhere in due course.

* * *

A Purely Vegetable Medium for the Cultivation of Micro-Organisms (*Dal Medium*).—Mr. A. C. Roy, of the School of Tropical Medicine, Calcutta, in the course of a paper read before the Biochemical Society, Calcutta, described the method of preparation of the *Dal* broth previously reported by Acton, Pasricha, Roy and Das Gupta (*Ind. Med. Gaz.*, 1932, **67**, 463). "According to the older technique, 500 grams of powdered *Mung-dal* (*Phaseolus mungo*) and 5 grams of papain, mixed with 5000 c c. of water, were digested at 60°–65° C. for four hours. The digestion of the *dal* for four hours at that temperature had the effect of splitting the *dal* proteins largely into amino acids. But since this *dal* broth was sought to be used as a substitute for the much more expensive peptone water, the time of digestion was reduced to one hour, when maximum peptone and very little amino acid formation took place. Various liquid and solid media such as *dal*-agar slopes, 0·5% bile-salt *dal*-agar plates (made on the same lines as MacConkey's bile-salt neutral-red lactose-agar plates) were prepared from this *dal* broth, which when diluted to contain 0·5% oxidisable matter was used as a substitute for 1% peptone solution.

"Some of the common intestinal organisms which one has to deal with in a bacteriological laboratory in India, *viz.*, Cholera and cholera-like vibrios, *Bact. typhosum*, *Bact. paratyphosum* A and B, *Bact. shigæ* (shiga), *Bact. flexneri* and *Bact. coli* were planted on the media prepared from this *dal* broth (by the modified method), using others in which peptone was employed as controls. With the *dal* media, the growth of these organisms was quite satisfactory and in most cases quicker and more vigorous than in the controls. Previously in the isolation of non-lactose fermenting organisms, there used to be many cases of failures with the *dal* the plates compared to the original MacConkey's plates. As a result of this modification the cases of failures have been considerably reduced. But even now it cannot be said that it gives as consistent results as the original MacConkey's plates.

"Attempts are being made to improve it still further so that it might be used as an efficient substitute for peptone water and in view of its extremely low cost of production (¼ to ½ anna per litre as against 6 to 10 annas per litre of

1% peptone solution) its economic significance is obvious."

* * *

The Institute of Chemistry.—A Joint Meeting of Members of the Indian Chemical Society (Bombay Section) and of the Institute of Chemistry was held on Wednesday, 5th September 1934 at 6-0 P.M. in the Chemistry Lecture Room of the Royal Institute of Science, Bombay, when Dr. R. C. Shah presided. There was an excellent attendance of members of both the Chemical Society and the Institute.

Dr. A. M. Patel read a paper on "Absorption of Dyes by Cellulose". The lecturer described how conclusions derived from results obtained in the last century were often erroneous due to impurities in the dyes and he explained present methods adopted to ensure purity.

The action of electrolytes in connection with absorption was mentioned and pointed out that the quantity of dye absorbed was directly proportional to the coagulating power of the electrolyte.

Absorption was rather a case of diffusion and varied with the thickness of the material and the salts used.

Methods for dyeing union fabrics, *viz.*, viscose and cotton, were described and it was pointed out that these have different affinities for dyes and that it was essential that they should be brought to the same degree which could be done by increasing the affinity or decreasing that of cotton or viscose. In attempting the former by mercerising, viscose is affected and therefore the affinity of viscose was decreased by steaming. The need for trained chemists to be in charge of dyehouse was particularly stressed.

A discussion took place mainly on practical points arising out of the lecture. The meeting concluded with the President thanking the lecturer for his most interesting lecture.

* * *

Association of Economic Biologists, Coimbatore.—A meeting of the Association was held on Thursday, the 23rd August, when the following papers were taken up for discussion.—(1) "*Soil Inoculation and Fungus Diseases.*" by P. D. Karunakar, dealing with the possibility of inoculating soils with saprophytic fungus, *Aspergillus* Sp., which may prevent or at least limit to a great extent the growth and activity of the parasite, *Fusarium monoliforme*. There are indications from the work done so far that this is possible. (2) "*Some Acarina of Economic Importance,*" by M. C. Cherian, deals with the *acarina* (mites and ticks) belonging to a group of lower animals of economic importance to the agriculturist. Some of these are parasitic on domestic animals sometimes acting as vectors of diseases. Some others by themselves cause skin diseases known as *Acariases*. Lastly, some are pests of cultivated plants. The part played by mites and ticks as pests of domestic animals has been studied to some extent in India but their relation to plants has not received adequate attention. The paper gives an account of the work done by the author on some South Indian Acarina with special reference to those forms found in Ganja, Sorghum, Sugarcane, Cotton, Castor, Rose, Figs, Grape-vine, Tomato, Brinjal, etc.

At a meeting of the Association held on the 20th September Mr. Abraham gave an interesting paper on the "*Preliminary Studies in the Anatomy of the Gynœcium of Cotton with special reference to Boll Dehiscence*". It has been observed in the indigenous cottons of Madras that the bursting of the bolls is rather bad in karunganni (*G. indicum*) as compared to uppam (*G. herbaceum*) and roseum (*G. N. roseum*).

An examination of the gynœcium in these varieties reveals certain anatomical features which appear to have a bearing on boll opening. Each carpel has three vascular bundles, a median and two lateral (placental). The folding of the carpels brings the margins along with the two placenta bundles close together and the margins get separated again during the dehiscence of the boll. In all cottons, the placental bundles of each carpel first arise separately from the receptacular stele, fuse together immediately and branch out again when they run through the placenta. It is observed that in dehiscence the cleavage of the carpel stops just above the region of fusion, the amount of dehiscence thus depending on the level at which this fusion takes place. In varieties belonging to species *G. indicum*, this region of fusion is situated at a much higher level than in other varieties with the result that the bursting of the boll is poor.

The inheritance of this anatomical feature has been under study in the progenies of crosses between *G. indicum* and *G.N. roseum* and between *G. indicum* and *G. sanguenium*, and there are indications that the character, bad opening, is a simple recessive.

* * *

Society of Biological Chemists, India.—During the month of September 1934 three meetings were held under the auspices of the Society when the following papers were presented:—(1) "The Control of Plant Diseases with special reference to Sandal Spike" by Mr. A. V. Varadaraja Iyengar, M.SC., A.I.C., A.I.I.SC., (2) "The Production of Mucus during the degradation of plant material" by Dr. J. G. Shrikhande, M.SC., PH.D., A.I.C., (3) "Influence of æration on the diastatic activity of the barley during germination" by Mr. R. H. Ramachandra Rao, M.SC.

* * *

Progress of Anthropology in European Universities.—Under the auspices of the South Indian Science Association, Rao Bahadur L. K. Ananthakrishna Ayyar delivered an interesting address on the "Progress of Anthropology in European Countries". The lecturer in his recent tour in Europe had the opportunity of visiting more than twenty famous Universities and of lecturing in a dozen of them. He gave an interesting account of the departments of Anthropology, the laboratories and equipments in these Universities as also of the teaching staff and facilities given to students for the study of the subject. The museums attached to the Universities contain a very large collection of specimens from all parts of the world and photographs to illustrate the racial types and cultural traits. In the Universities of Naples, Rome, Paris, Vienna, Berlin and others there are separate departments and museums to facilitate the study of Physical Anthropology, Ethnology and Ethnography. The museums in England are equally grand. The papers and books published by the professors of these Universities are abundant. The study of Indian Ethnology in these Universities leaves much to be desired.

Mr. Ayyar gave in contrast the study of the subject in India and emphasised the necessity for much more encouragement and the introduction of the subject in the under-graduate and post-graduate studies of Indian Universities. At present it is only the Calcutta University that has a fully developed department of these subjects.

* * *

Royal Institute of Science.—Principal Dr. T. S. Wheeler has been elected as Dean of the Faculty of Science and a member of the Syndicate of the Bombay University.

Dr. Ludwig Wulf, Prof. of Textile Chemistry in the Andhra University, visited this Institute on 19th September, 1934, and saw the equipment and work in the Chemistry Department.

Mr. G. V. Jadhav, M.Sc., of the Chemistry Department has been awarded the Sir Mangaldas Nathubhoy Foreign Scholarship.

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Dr. G. C. Chakravarti, D.Sc., Lecturer in the Department of Organic Chemistry, Indian Institute of Science, Bangalore, has resigned his appointment for reasons of ill-health. The staff and students of the department met under the presidentship of Dr. P. C. Guha, D.Sc., on Saturday, the 15th September 1934, and passed a number of resolutions placing on record their appreciation of the valuable services rendered by him.

Dr. Chakravarti's contributions relate chiefly to the chemistry of the dye-stuffs. Just prior to his retirement he had begun an investigation on the natural colouring matters of "Alkanet" and suggested a tentative constitution for "Alkanin". It is rather unfortunate that he could not complete this interesting enquiry.

* * *

University of Lucknow.—Dr. S. N. Das Gupta has been appointed to the post of Reader in Botany at Lucknow University, vacated by the death of Dr. S. K. Mukerji, F.L.S. Dr. Das Gupta is a Ph.D. of London University, with special qualifications in mycology, a field of research to which he has made important contributions, published in the *Annals of Botany* and in the *Philosophical Transactions of the Royal Society*. Special mention may be made of his discovery of a remarkable relationship between the two strains of *Diaporthe perniciosa* DH_C and DH_F, in which the slow-growing strain DH_C cultivated in contact with the fast growing DH_F dominates the latter, and is able to convert it into its own type.

* * *

Indian Coriander.—According to a press communique issued by the Secretary, Imperial Council of Agricultural Research, Simla, published in a recent issue of the *Indian Trade Journal*, a detailed examination of the samples of Russian, Moroccan, Tuticorin and Rangoon corianders, as also a typical trade sample from the Udumalpet (Coimbatore District) market, revealed that the Indian Produce which is of intrinsically good quality, is losing ground mainly by reason of adulteration of the clumsiest character. The Tuticorin sample contained, 0·3 per cent. stalk, 0·3 per cent. extraneous seeds and other grains, and 20·0 per cent. dirt. The Moroccan produce contained about 0·3 per cent. stalk, about 0·3 per cent. extraneous seeds and other grains, and less than 1 per cent. dirt. The essential oil content which may be said to determine the pungency and efficacy of coriander, was about the same in both Indian and Moroccan samples, and perhaps the former showed a rather higher trend. These data clearly indicate that with "even reasonable attention to cleanliness Indian coriander can easily hold its own and it is important that steps to this end should be taken, for India cannot afford to lose any of its markets for these minor agricultural products which in the aggregate mean so much to the cultivator and market gardener."

* * *

Lorentz Collected Papers.—Martinus Nijhoff, publisher of "Lorentz Collected Papers" writes: "I have resolved to go on with the publication and the 8th volume (the 2nd of the set of 9 volumes) is already in the press. Vol. VII, the 1st of the set, appeared a few months ago.

"I beg to draw once more your attention to the fact that immediately after the publication of this volume—about November 1934—the work will be no longer available at subscription price.

"Subscribers to the 9 volumes may have the set for 75 *guilders*, or bound for 90 *guilders* (payment after the publication of each volume, Gld. 8.35 or Gld. 10). Afterwards the price will be 90 guilders, or bound 108 guilders."

* * *

The Prague International Samples Fair, 1935.—The Spring session of the above fair will be held at Prague from 3rd to the 10th March 1935. Firms wishing to participate in this fair may obtain full particulars from the Consul for Czechoslovakia, 34, Park Street, Calcutta.

* * *

Increased World Activity in Chemical Research.—The Editor of *Chemical Abstracts*, Prof. E. T. Crane of the Ohio State University, draws attention to the increased output of chemical papers in 1934. Digests of papers appearing in 2,000 scientific and technical journals number 18,664 in the first six months of 1934 as against 17,648 in a corresponding period of 1933. "This increase is heartening from an economic standpoint because of chemistry's basic association with practically all of the industries. It indicates that thousands of chemists throughout the world are turning out a steady stream of new information vital to industrial and social progress."

* * *

"*Element* 91."—For the first time, a powerful radio-active substance similar to radium and, it is said, equally useful in the treatment of cancer, has been isolated. Dr. Aristid von Grosse of Chicago University, who has isolated this element, called protactinium, says that while a gram of radium costs £20,000 to £25,000, a similar quantity of protactinium will cost only £600. The American Chemical Society meeting at Cleveland has been shown the element, plainly visible under a magnifying glass as tiny silvery beads. It is the rarest metal in nature, for out of 10,000,000 parts of pitch-blende only one part of protactinium can be extracted. Even more important than the isolation of this element is the fact that Element 91 naturally disintegrates into actinium, which is 140 times more active than radium. Until her death the late Mme. Curie worked unsuccessfully on the isolation of

actinium, which Dr. von Grosse says will in a year or two be available to science and medicine. (*Chemical Age.*)

* * *

According to a report in *Hindu* the Allahabad University Teachers have been allowed to seek elections to the Legislative Assembly and other Councils under certain conditions. Thus a teacher seeking election should obtain permission from the Executive Council, after satisfying them that his absence in connection with his electioneering work or work connected with the legislatures would not interfere with his University duties.

* * *

The Hilger Vitameter A.—Adam Hilger, Ltd., 98, King's Road, Camden Road, London, N.W. 1, England. (Hilger Publication No. 151/5. Post free on request.) This booklet (the fifth edition) describes the latest model of the Hilger Vitameter A for determining the Vitamin A content of cod and other fish liver oils and concentrates.

This model is of all-metal construction and embodies optical and mechanical improvements.

It may be remembered that the instrument is based on the now accepted spectrophotometric method of test. Measurements are made visually by comparing the intensity of two fluorescent areas and rendering them equal by a photometric device whose scale gives readings that are a direct measure of the Vitamin A content.

The makers claim that the instrument, which is extremely simple to use, gives accurate results even in the hands of unskilled operators.

* * *

Indian Research Fund Association.—Applications are invited from experts on Nutrition to undertake independent charge of Nutritional Research under the Indian Research Fund Association at Coonoor, a hill station (6,000 ft. above sea-level) in the Madras Presidency of India. Pay in the scale of Rs. 1,250–100–1,750 with usual departmental travelling and halting allowances. In addition, an overseas pay of Rs. 500 per mensem will be given to a person of non-Asiatic domicile if appointed. The commencing pay of the selected candidate may be fixed at a higher rate than the minimum of the scale of Rs. 1,250–100–1,750 if the experience and qualifications of the candidate selected justify this. All applications must be made on the prescribed form copies of which can be had from the *Secretary, Indian Research Fund Association, Civil Secretariat, Simla* (upto 19th October and thereafter, New Delhi). Final date for receipt of completed forms of application is 30th November 1934.

* * *

Novel pH Meter, "Pehavi".—Announcing new type Hartmann and Braun Instruments placed in the market their Agents for India, Messrs. Adair, Dutt & Co., Ltd., have drawn our attention to several instruments in which compactness, accuracy and simplicity in manipulation have been combined in a very efficient manner. Of these great interest is being received for the new pH measuring potentiometer "*Pehavi*" which is most suitable for the Sugar Laboratories, the Clinical and Pathological Laboratories and the Chemists. This has both a pH scale—in two ranges—and a Millivoltmeter scale. Thus either a Platinum Hydrogen or a Quinhydron Electrode or any other type of Electrode can be used and for each the scale is brought into view by a rotating switch avoiding any possibility of confusion. No Standard Cell is necessary at all as the instrument is calibrated for any dry battery as is used for pocket lamps. Equally important are the two types of Universal Voltmeters "*Multavi-I*" and "*Multavi-II*" having multiple ranges in volts, amperes and milliamperes for both D.C. and A. C. and are also available for measuring resistance with the help of any dry battery or the L.T. and H.T. batteries as are used in Radio work. The "*Pontavi*" is a compact resistance bridge capable of measuring from 0·05 to 50,000 ohms and contains an enclosed dry cell and a built-in sensitive pointer Galvanometer. We are sure these new instruments would arouse keen interest amongst the general Scientists, Radio Amateurs and Technical people.

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We acknowledge with thanks the receipt of the following:—

"The Journal of Agricultural Research," Vol. 48, Nos. 11 and 12; Vol. 49, Nos. 1, 2 and 3.

"List of Publications on Indian Entomology," 1931, 1932. Miscellaneous Bulletin, Nos. 2 and 3. (Imperial Council of Agricultural Research).

"Journal of the Indian Botanical Society," Vol. 13, No. 1.

"Chemical Age," Vol. 31, Nos. 791-794.

"Berichte der Deutschen Chemischen Gesellschaft," Vol. 67, No. 9.

"Journal of the Indian Chemical Society," Vol. XI, Nos. 7 and 8.

"Experimental Station Record," Vol. 71, No. 2, August 1934.

"Educational India," Vol. I, No. 3.

"Forschungen und Fortschritte," Jahrgang 10, Nos. 25 and 27.

"Indian Forest Records," Vol. 20, No. 10.

"Monthly Statistics of the Production of Certain Selected Industries of India," July 1934, Government of India Publication No. 4 of 1934-35.

"Forest Bulletin" No. 86 (1934) Sylvicultural Series—Cold Weather Planting in Northern India.

"Agricultural Statistics of India" (1931-32), Vol. I.

"Administrative Report" (1108 M.E.), Archæological Department, Government of Travancore.

"Mathematics Student," Vol. II, No. 2.

"Medico-Surgical Suggestions," Vol. 3, No. 9.

"Memoirs of the Indian Meteorological Department," No. M/2 Meteorological conditions affecting aviation over the North-West Frontier.

"Journal of the Indian Mathematical Society," Vol. I, No. 2.

"Nagpur Agricultural College Magazine," Vol. 9, No. 1.

"Nature," Vol. 134, Nos. 3382-3385.

"Natural History," September 1934.

"Journal of Chemical Physics," Vol. 2, Nos. 8 and 9.

"Review of the Scientific Instruments," Vol. 5, No. 8.

"The Indian Trade Journal," Vol. CXIV, Nos. 1473—1476.

Reviews.

TIRUPPARUTTIKUNRAM AND ITS TEMPLES. By T. N. Ramachandran, M.A. (*Madras Museum Bulletin*, Volume I, Part iii.) Editor: Dr. F. H. Gravely.

The project of issuing, at least of resuming the issue of, the Museum Bulletins was revived a short time since through the exertions of Dr. Gravely, and is being actively carried into effect. This Bulletin constitutes the third of the series in this particular Department. Kanchi, the modern town of Conjeevaram, had achieved a great name as a *ghaṭika* or a Brahman settlement before the Christian era. It had a similar reputation as a centre alike of the Buddhists and of the Jains as well. While the town Conjeevaram, as it is at present, probably constituted the Brahmanical centre as the number and the location of its varying temples would suggest, the Buddhist centre seems to have been just outside the limits of the now existing town and occupied a quarter distinctly its own. So probably it was with the Jain quarter, and the village Tirupparuttikuṅram about a couple of miles off, on a side just opposite the Buddhist centre, gave it the reputation of a Jaina centre and possibly stands for the Jina Kanchi of literary fame. The name Tiruppa-ruttikuṅram is apparently given to it after a hillock or a rise of ground distinguished from the surrounding part by cotton cultivation, the kind of cotton which goes by the Tamil name *Parutti*. This would be nothing strange as in the same district and perhaps not very far off we have the village Paruttipaṭṭu, probably from the same feature. Mr. Ramachandran attempts here to equate the name with another in the same locality called Śemporkuṅru, translated into Sanskrit Aruṇagiri (red hill). The equation is hardly tenable and is quite unnecessary, as the latter would be the name of a particular hill in the same locality without any notion of an identification.

Its present importance, and perhaps its importance for the last 1200 years or more, is due to its having been an important Jain settlement with two of the Jain *bastis*, one dedicated to Chandraprabha, the 8th of the 24 Tirthankaras and another, and a larger one similarly dedicated to Trilōkyanātha Vardhamāna, the 24th among them. The first temple probably goes back to Pallava times from its architecture, and is assigned to the reign of Paramēśvaravarman II, the Pallava king. It is possible that it began with the reign of his predecessor, Narasimha Varman II, Rājasimha, the builder of the Kailāsanātha Temple at Conjeevaram. The Vardhamāna temple is more closely datable from the inscriptions of which a large number have been made available in this Bulletin. A number of these have already been edited by the epigraphists, and a number more have been newly brought to light. References are given to the former and the latter are published with transliteration and translation by the editor. From these we are enabled to make the inference that the temple probably began at the end of the Pallava age and received support from the Chōḷa rulers from the days of Rājēndra, the Gangaikoṇdachōḷa, in the first half of the eleventh century, right down to Kulōttuṅga Chōḷa III and Rāja Rāja III ruling the Chōḷa empire at the commencement of the fourteenth century. This is a double shrine dedicated to Vardhamāna, the 24th Tīrthankara. A number of subsidiary shrines there are in it such as the temples to Pushpadanta, Dharmadevi, Padmaprabhā, Vasupūjya and Pārśvanātha. This shrine constitutes the earliest part of the building to which a front hall or verandah was added in Chōḷa times and a larger hall still under the first dynasty of Vijayanagar. This was dedicated by the Vijayanagar general Irugappa, while his father also seems to have been devoted to the shrine, as both of them came to be disciples of the Jain saint Pushpasēna, who was a permanent resident of the locality. Further additions were made to these structures by Pushpasēna himself who is responsible for the *gōpura* in front. Even the great king Krishnadēvarāya of Vijayanagar made a grant of land. So we might say the place has been an active centre of the Jains from the eighth to the sixteenth century.

Among the Jain saints associated with the place the most important are Akalanka about the eighth century of whom there is but little of a memorial in the locality, and of the more recent ones, Chandrakīrti, the contemporary of Kulōttuṅga III, and his disciple Ananta Vīrya Vāmana belonging to the twelfth and thirteenth centuries. And later still belonging to the end of the fourteenth and the early part of the fifteenth century are the two Mallisēna Vāmana and

Pushpasēna, his disciple; the former was the preceptor of Bichappa and is the author of a number of Sanskrit works such as *Panchāstikāya*, *Pravachanasāra*, *Samayasāra*, and *Syādvāda-manjari*. He was also the author of the Tamil *Mērumandarapurāṇam* published recently by Principal A. Chakravarti of the Kumbakonam College with a commentary written by his father. This Mallisēna is also believed to be the author of the Tamil commentary *Samaya Divākara* on the Tamil work called *Nilakēśi Tiruttu*. This Bichappa was the general of the Vijayanagar emperor Harihara and his son Bukka II. His son Irugappa's name is connected with the *Mērumandara Purāṇa* and there is a statue of his in the Jain temple itself, so that the name Jinakānchi would have been well bestowed on the place and equally well deserved by it.

Coming to the temples themselves, the complex character of its structure tells its own tale in regard to the age of the several parts going to constitute the temple. Apart from the temples and images, the feature that is most prominently noticeable is the series of paintings of scenes from the lives of the saints. These are a most important feature of Jaina shrines, as in fact of Indian shrines generally. While one way of popularising religion was that of reading or rendering to musical accompaniments the stories of saints to the people who gather together on occasions of pilgrimage, this method could be reinforced by ocular demonstrations by pictures. These paintings were intended to serve the latter purpose There are 22 Plates of these representations relating to the life of the first Tīrthankara Rishabhadēva, the 22nd Nēminātha and the 24th Mahāvīra. Each one of these carries a label. Along with these are found a number of paintings representing the playful activities of Krishna whom the Jains regard as a cousin of their Tīrthankara Nēminātha. There are the lineal descendants of paintings leading back to the caves of Ajanta in India, and Śrigiriya in Ceylon as also those of Sittannavāsal and places like that. Mr. Ramachandran, the Archæological Assistant at the Museum, has been at pains to explain these pictures from Manuscript works containing material for it, and has brought together, in addition to this, a volume of information of a more recondite kind in regard to Jainism in general. Both he and the editor, Dr. Gravely, deserve congratulation for the illuminating volume of 235 pages of the monograph itself and 24 pages of index together with 36 plates of illustrations. The Government Press which is responsible for its printing, it need hardly be added, has done its work with its usual excellence.

S. K. AIYANGAR.

THREE ESSAYS ON SEX AND MARRIAGE. By Edward Westermarck. (Macmillan & Co., Ltd., St. Martin's St., London. (Pp. ix+335. 1934.) Price 12*s*. 6*d*. net.

These essays enitled "The Oedipus Complex, Recent Theories of Exogamy" and "The Mothers: a Rejoinder to Dr. R. Briffault" are intended to supplement Dr. Westermarck's "The History of Human Marriage". They are a thorough, closely reasoned and critical exposition of some of the obscure aspects of human mind and should be esteemed as a valuable contribution to social science.

The first part of the book is devoted to a criticism of the Freudian doctrine of the Oedipus complex and its technique, psychoanalysis, and the author concludes that the theory of unconscious makes assumptions not warranted by the facts of direct observation, accumulated by anthropological studies. It seems to us that the divergence of views between the anthropologists and the Freudian psychologists is due to the fact that they are dealing with two classes or aspects of mind from entirely different standpoints; and their methods of investigation of even common problems are bound to differ. The Freudian technique is the outcome of the development of medicine and explains the causes of hysteria and other forms of mental obsession including dream phenomena. It assumes the existence of an unconscious part of mind, the repository of repressed wishes which when the mental censor relaxes vigilance, express themselves symbolically. The business of the psychoanalyst is to explore the sewers of the human mind, slips of the tongue and pen, casual statements of children and refer them to experiences of childhood; and in pathological cases he devises suitable formulas for the removal of apprehensions and obssessions which are believed to be at the basis of the hysterical and allied maladies. The business of the anthropologist is not with the unconscious mind and unconscious statements: his province is the normal conscious mind of adult persons, in its relation to the social,

cultural and economic evolution of the peoples, and to discover law and order in the progress of human civilisation. The common ground of anthropologists and Freudian psychologists is sex which like the human mind has apparently two aspects, the official and the unofficial. The anthropologists study both the aspects in their relation with the family and communal organisation, religious and mystical practices without attempting to investigate and interpret the origin of the unofficial aspects of sex life and its bearing on the pathological and seemingly unaccountable manifestations of mind. This is the province of Freud's school.

We have read this book with that close attention which its importance deserves. It is written in self-defence. It refutes the cherished theories of Freudianism. It ridicules Dr. Briffault's criticisms of the author's views on exogamy and the relations between the sexes in primitive humanity and the early forms of marriage as expounded in his standard work, "The History of Human Marriage". It is true that the theories of Freud make great claims and the rôle which they play in the psychology of the individual is the proper field of investigation by the neurologists; but the social facts underlying the supposition of their universality and the influence they are alleged to have exercised on the history of civilisation must be the principal concern of sociologists. We are not, however, prepared to agree with Dr. Westermarck that the sociological presuppositions of Freudian doctrines are utterly unfounded, for if the human body is a derivative of some simian ancestor, the human mind cannot be an innovation. The psychologists and neurologists and sociologists who find the human mind as an abstract concept in its ultimate analysis, have not investigated the animal mind with any measure of comprehensiveness. If the human mind suffers from "Complexes", they must be part of the animal heritage with which man arrives in the world. The validity of Freudianism requires support or meets with refutation from investigations of the simian mind.

It is idle to claim that any one theory offers adequate explanation to the various types of prohibitions and alliances introduced by society in the sex relations of its members. For the perpetuation of species, Nature has provided the animals including man, with the means of securing the union of two micro-organisms of different kinds and society has elaborated round this simple process a most complex body of rituals, superstitious faiths and sanctions. Their number and mode of application depend upon the cultural strata of society: they must have evolved independently. The object of organising social groups must be the same throughout the world, and the different forms of societies must have attained their common purpose through different routes. Marriage as it is understood in civilised societies, may be discussed from the standpoint of law, religion, social and economic science or biology; its various forms, the superstitions and rituals that have developed round this institution and the conditions and sanctions prescribed by social legislators must be the outcome of various considerations in the interests of the purity and efficiency of the members entering into matrimonial relations. The accounts of these considerations, when we examine a large number of groups, must differ and might even appear conflicting: and the divergence of views between Dr. Briffault and Dr. Westermarck must be largely a matter of opinion. Even if Dr. Briffault had carefully verified his references before criticising Dr. Westermarck, there is bound to be difference of opinion about usages and their origin, because the interpretation of anthropological facts must in a large measure depend upon personal factors rather than upon abstract rules such as those derived from experimental sciences.

Everyone interested in social science will welcome this scholarly and informative book.

PROPERTIES DES ESPACES ABSTRAITS LES PLUS GENERAUX. By Prof. Appert. (Hermann et cie, Paris, 2 Vols.) Price 24 Francs.

A proper understanding of the axiomatic development of the theory of open and closed sets, continua and domains, and some important characteristics of the subject, such as compactness, Borel-Lesbesgue property (Heine Borel), separability of various degrees and the corresponding Lindelöfian property, etc., is a *sine qua non*, for the study of analysis, especially of the theory of functions of a real variable and the theory of analytic functions. The usual development of this subject given in older textbooks such as Hobson, is too highly restricted as the proofs apply only to Euclidian space and also they do not clearly indicate

how the various axioms of Euclidian space are involved in the proofs of various theorems. As a matter of fact in many of the theorems about neighbourhoods as developed in Hobson, the particular structure of Euclidian space plays no part.

Coming now to the two volumes of Prof. Appert on "Properties of Abstract spaces of a very general kind" as the title itself indicates, he develops the theory of open and closed sets, continua, etc., in such a manner as to be valid in the most general of spaces which he calls topological and naturally, it is completely free from the various defects, mentioned in the first paragraph, which characterised the older books. The subject is developed in a very logical and extremely interesting manner.

Vol. I—The first few chapters deal with the properties displayed by sets of points of topological space, with regard to the operation of derivation under the 1st, 2nd and 3rd axioms or conditions of F. Riesz. The sixth chapter deals with generalisation of continua and domains in generalised *space*.

The topics of discussion of Vol. II are very important and among them the most interesting theorem is that of Chittenden which proves that the necessary and sufficient condition that a set of points should have the Borel-Lesbesgue property is that the set should be perfectly compact in itself. Some of the other interesting topics deal with generalisation of (1) Cantor's Theorem on a monotone sequence of closed sets, (2) Cantor-Bendixon's Theorem, (3) Separability of various degrees....etc.

Although at a number of places examples are given showing the independence of the various axiomatic assumptions and exemplifying the various abstractly defined elements, as for example, on page 19, Vol. I, and on page 64, Vol. II, I think that there are not enough examples in the book illustrative of the various definitions. I conclude that it is an excellent book embodying some of the latest work on the subject and every student of analysis would benefit largely by a good study of the book.

K. S. K.

LE CALCUL SYMBOLIQUE. By Pierre Humbert. (Hermann et cie, Paris, Pp. 31.) 10 Francs.

An outline of the methods of Heaviside's operational calculus is presented. The author has given references to Carson and Paul Levy for rigorous treatments of the subject. Some applications of the operational calculus have been dealt with; for example, the author deduces the addition formulæ and a new formula in Bessel functions. References may be made to the author's published papers (Nouvelles remarques sur les function de Bessel du troisieme ordre, *Acta. Pontif. Acad. Sci.* Novi, Luncæi, 1931, **87,** 323 and Les fonctions hypergeometriques et le Calcul Symbolique, *Ann. Soc. Sci.*, Brux, 1933, **A53,** 103).

N. S. N.

EXERCISES IN SECOND YEAR CHEMISTRY. A Manual of Theoretical and Analytical Procedures. By William H. Chapin, Third Edition. Revised and Enlarged. (Published by John Wiley & Sons.) Pages 253. Price 15*s.* 6*d.*

This book is meant to be a companion volume to the author's *Second Year College Chemistry*. The author has dealt with a variety of topics of physico-chemical and analytical interest under two main divisions: (1) theoretical exercises, (2) quantitative analysis. In Part I a series of experiments in Physical Chemistry not involving difficult technique or complicated apparatus have been described which go a long way to a clear understanding of the subject on the part of a beginner. The reviewer would like to draw attention to the elegant experiments in the chapters on Avogadro Number, neutralisation indicators, etc. Coming to Part II which deals with quantitative analysis mention should be made of the excellent theoretical background that is provided for the course in volumetric, gravimetric and electro-analysis. The chapter on pH, water-softening control, etc., is particularly interesting. Every topic treated in the book is followed by a number of problems and exercises.

The printing and get-up of the book are excellent. The pyroxylin-impregnated "water-proof" and "vermin-proof" binding is a novel feature. The book will be very useful as a reference volume to students studying for B.Sc. and Honours examinations.

M. SESHAIENGAR.

MAN AND MEDICINE. *An Introduction to Medical Knowledge.* By H. E. Sigerist. Translated from the German original by Margaret Galt Boise. Pp. v+340. (London: George Allen & Unwin, Ltd.) 1933. Price 12*s.* 6*d.* net.

Although there are several monographs dealing with the theory and practice of medicine, there are few publications which deal with the subject in such a manner that even laymen can follow them. Prof. Sigerist's lucid presentation of the subject is therefore a welcome contribution.

The book covers the entire field of science in relation to medicine. The author skips on from one section to another without losing the thread of continuity. At each stage, the subject is made interesting by historical anecdotes which bring into relief the human interest underlying each discovery referred to by the author.

If the book has any defect, it is that the author is too ambitious, that he has endeavoured to cover a vast field of knowledge in the short space of 329 pages. Even technical readers, many of whom are unfortunately unacquainted with the historical development of their subjects, would like to linger over some of the sections and learn more about the various factors, human and otherwise, that led to the great discoveries in their respective fields. It would indeed have been highly desirable if the scope of the book had been restricted to a few select branches, the others being reserved for later publications.

The book has been written in excellent style and the translator deserves much praise for her efforts.

S. V.

ELEMENTARY SCIENCE. (Parts I & II.) By James B. Guthrie, M.A., B.Sc. (Chambers Limited, Edinburgh.)

Part I. Pp. 112. Price 1*s.* 6*d.*

This is the first of a series of four books, by James Guthrie, Principal teacher of science and mathematics of Buckhaven Secondary School. These books are in accordance with the most recent circulars of the Board of Education and the Scottish Education Department. Part I deals with subjects like Expansion and Contraction, Thermometry, Solution and Crystallisation, Rusting of iron, Physical and chemical changes, Atmospheric pressure and transfer of heat. The book is written in very simple language. Experiments precede generalisations and definitions. Difficult terms are explained at length. Experiments are designed to be simple and capable of being tried by the enquiring student. Hints to the teachers are given here and there. The figures indicating apparatus used for experiments are drawn in a neat and attractive manner. The portions dealt with in the book are meant to be covered in a year with four periods a week.

Part II. Pp. 127. Price 1*s.* 8*d.*

This book is meant to cover the science syllabus of the second year in schools and deals with subjects like Force, Centre of Gravity, Density, Pressure, Machines Work, Latent Heat, Action of Metals on the common acids. Preparation and properties of hydrogen and composition of water, Questions and Exercises and Answers to them are given.

The language difficulty experienced by the Indian student will be minimised when a text-book like this is placed in his hands. It is a highly useful and instructive book, worthy of being tried as a text-book in our Indian High Schools. These books become more commendable owing to their attractive printing and get-up.

B. V. SASTRY.

Forthcoming Events.

The Central College Mathematical Society, Bangalore.—Fortnightly Lectures on "Introduction to the General Theory of Algebraic Numbers" by Mr. K. Venkatachala Iyengar.

Fortnightly Lectures on "Quantum Mechanics" by Prof. B. S. Madhava Rao.

Erratum.

Vol. III, No. 3, page 106, Col. 2, line 8, *for* P. F. MALLIK *read* P. C. MALLIK.

1728-34.—Printed at The Bangalore Press, Bangalore City, by T. Subramania Aiyar, Superintendent, and Published by B. N. Sastri, M.Sc., A.I.C., A.I.I.Sc., for the "Current Science" Board of Editors, Indian Institute of Science, Hebbal Post, Bangalore.

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